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Physics procedures

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Introduction

This document was produced as a result of a project looking into physics practical methodologies. Our aim is to support and enable educators with experimental work.

You are free to reproduce these materials, however we do require that there is a clear attribution. This should be in the following form:

“This document was created by the University of Strathclyde Institute of Education”

Where individual pages are printed, these should include the current header and footer.

These materials are created as guidelines and any risk assessment or necessary alterations to ensure the safety of the instructions should be undertaken in accordance with your establishment’s policies and procedures.

If you would like to add to this, or have requests/suggestions for additional activities, please let us know.

Thanks

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and

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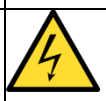
Co-Authors

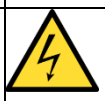
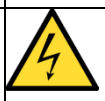
Health and Safety Information

Use of Portable Electrical Equipment

Staff only

Item	Hazards	Control Measures
Portable electrical equipment	 Electric shock	Ensure equipment has been PAT tested, and perform visual inspection. Take care using near sinks – move as far away as possible.

Staff and students

Item	Hazards	Control Measures
Portable electrical equipment	 Electric shock	Take care using the equipment near sinks – move as far away as possible. Carry the equipment carefully to avoid damaging the internal components/casing/cables. Choose low voltage equipment where practicable. Ensure the use of extension cables is limited. When connecting leads to equipment, 4mm sockets on equipment should only be connected to other equipment by 4mm leads which are available in the lab.
High Tension (HT) and Extra High Tension (EHT) equipment	 Electric shock	When using HT equipment, ensure the following controls are adhered to: Engineering Controls – Shrouded socket outlets – Shrouded terminals – Enclosure of HT conductors in apparatus – Meters with minimalist features (only 2 sockets and no current settings) Administrative Controls – Warning notice on HT power supply, and beside equipment – Pupils under 16yrs or S5 must not use equipment Clear instructions given to senior pupils on safe use Shrouded leads must be used with HT and EHT equipment

Background Information

Mains Electrical Equipment

All mains electrical equipment has to undergo a regular Portable Appliance Test (PAT). A sticker that claims that a piece of electrical equipment has been PAT tested only tells you that the equipment was satisfactory on the day of the test. Whilst you should check that any mains equipment you are issuing has indeed been tested, you should also conduct some quick visual tests each time you hand it out:

- Is the flex free from damage?
- Is the casing free from cracks?
- Is the plug free from cracks and is the outer insulation of the flex firmly gripped by the plug's cable clamp?

Power Supplies

The classification of power supplies used in education is shown below:

Power supply type	Voltage output	Current output	Hazard
LT (Low Tension)	25 V* maximum	<9 A	Generally no risk of electric shock except in applications with inductors. Risk of burns or fire
HT (High Tension)	Generally 400 V maximum	Unlimited. Maximum values typically lie between 80 mA and 400 mA	Hazardous live Risk of electrocution
EHT (Extra High Tension)	5 kV	5 mA absolute limit Typical maxima are 2 mA or 3 mA	Either outwith, or just inside, the hazardous live regime. Risk of harm is unlikely

Table taken from SSERC Bulletin 208
Power supplies are classified by their electrical outputs and the hazards presented
*For more information, please see the notes on Power Supplies

The HT power supply is the only type that clearly presents a risk of electrocution. These have a limited application in physics, chiefly with the Teltron Fine Beam tube, Teltron Critical Potentials tube and Neon lamp excitation.
If working with an HT supply, or indeed hazardous live in general, the following control measures should be taken, where appropriate:

HT Supplies - Engineering Controls:

- Shrouded socket outlets on HT supplies
- Shrouded terminals on apparatus (see picture)
- Enclosure of HT conductors in apparatus
- Leads with shrouded connectors
- Meters with minimalist features (Only 2 sockets and no current setting. Leads to GS38)

HT Supplies - Administrative Controls

- Warning notice on HT power supply
- Pupils under 16 years or S5 must not work with HT circuits
- Instruction given to senior students on HT working arrangements
- Warning notice placed beside HT circuit

Use of Laser Equipment in Light Experiments

Staff only

Item	Hazards	Control Measures
Laser	 Eye damage	Ensure laser has been PAT tested and perform visual inspection. Ensure laser is either class 1 or 2. Laser pointers are unclassified and must only be used by staff for demonstrations/presentations.

Staff and students

Item	Hazards	Control Measures
Laser	 Eye damage	Laser must be switched off when not in use. Experiments must be supervised at all times. Do not stare into the beam. Laser should never be pointed at anyone.

Equipment Information

Motion QEDs and TSAs

These are self-contained units designed to store and calculate time, speed and acceleration.

Unilab Motion QED

DJB Microtech TSA (Old)

DJB Microtech TSA (New)

The QEDs and TSAs must be connected to light gates. There are various options available:

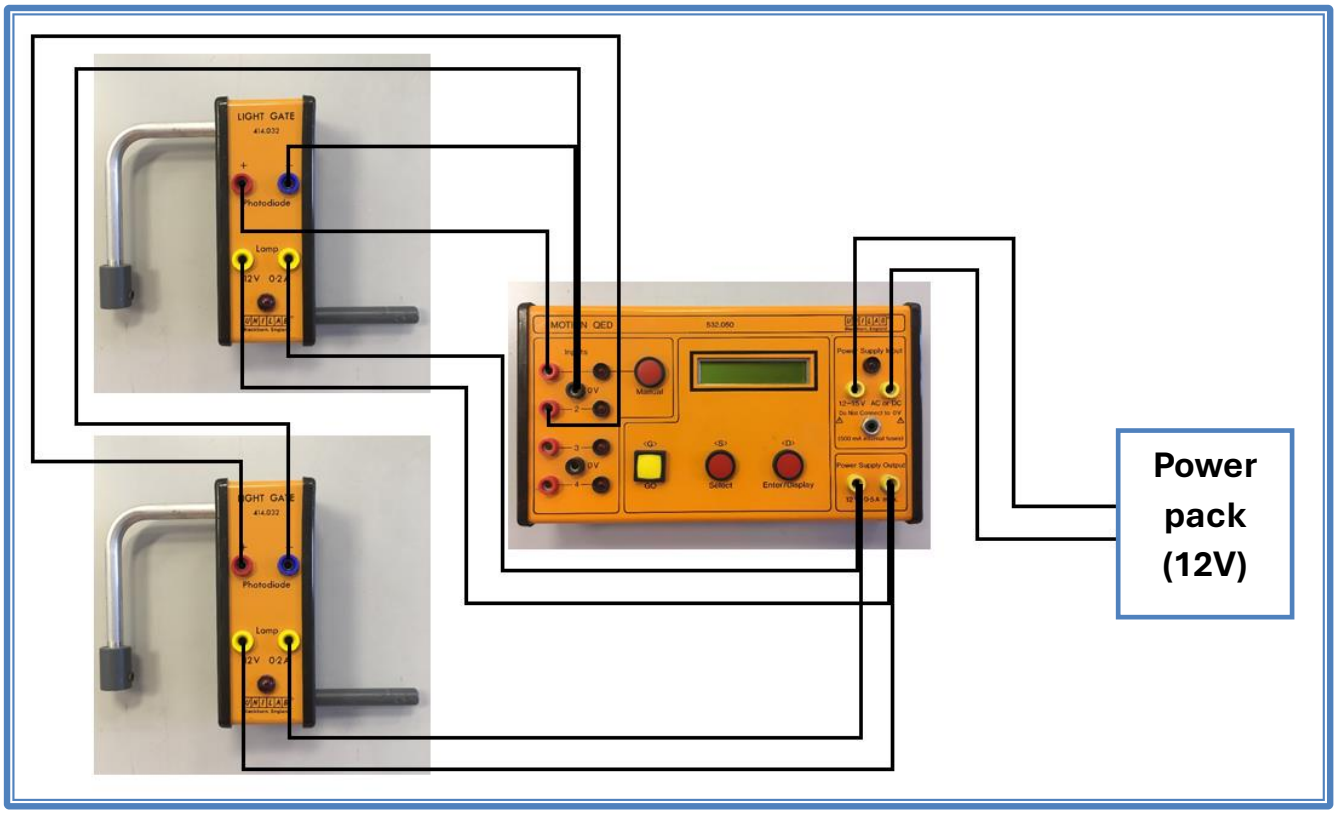
Unilab light gate, model 414.032
Can be used with the Motion QED and TSA

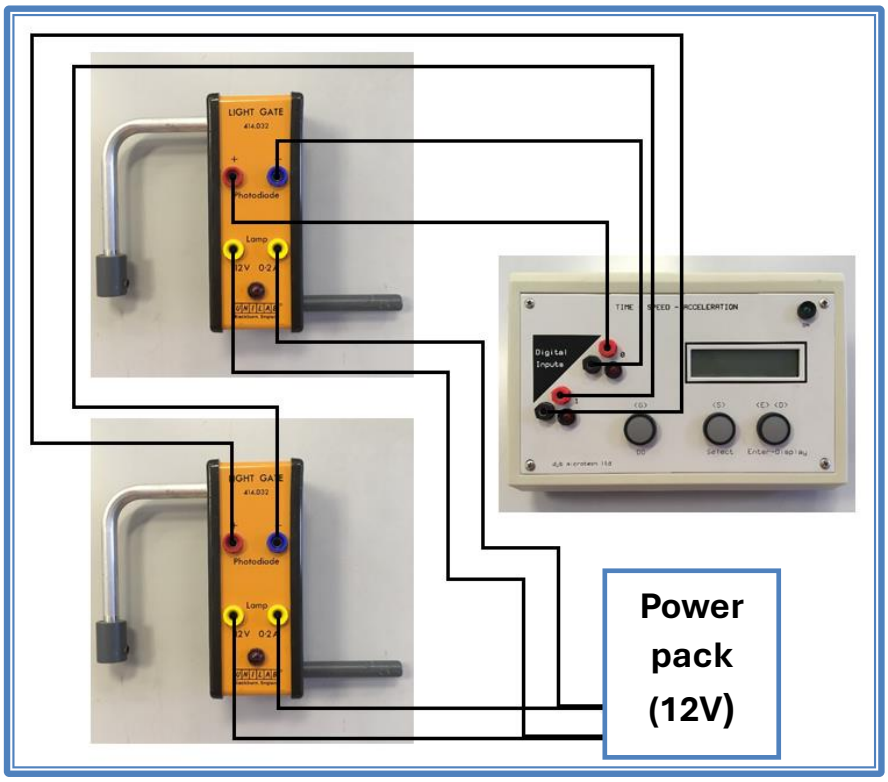
Unilab light gate, model 414.033
Can be used with the Motion QED and DJB Microtech TSA (Old)

DJB Microtech Light Bridge
Can only be used with the TSA. Light source + receiver connected by metal rod to aid set up.

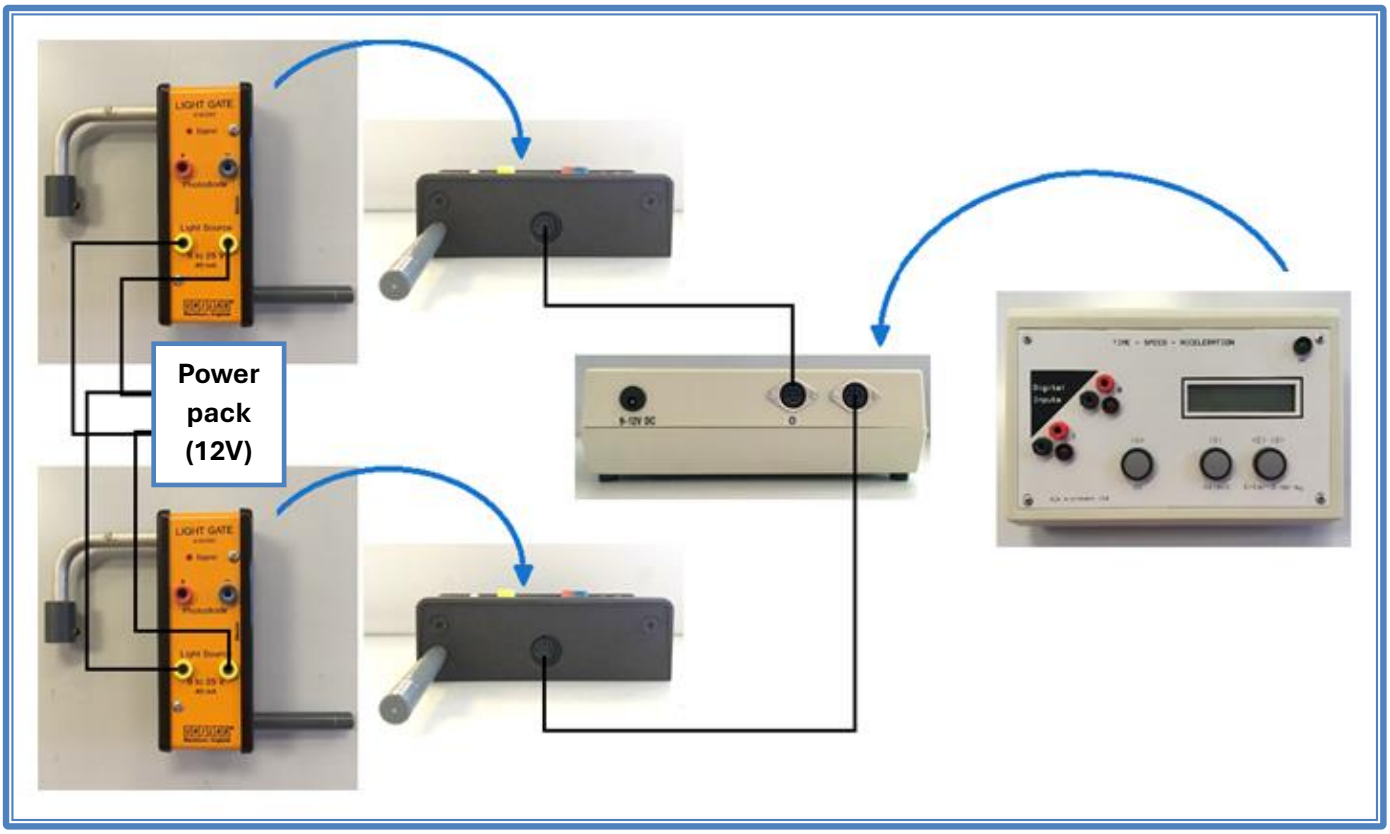
DJB Microtech Light Bridge
Can only be used with the TSA. Light source + receiver separate, so must be lined up correctly to work.

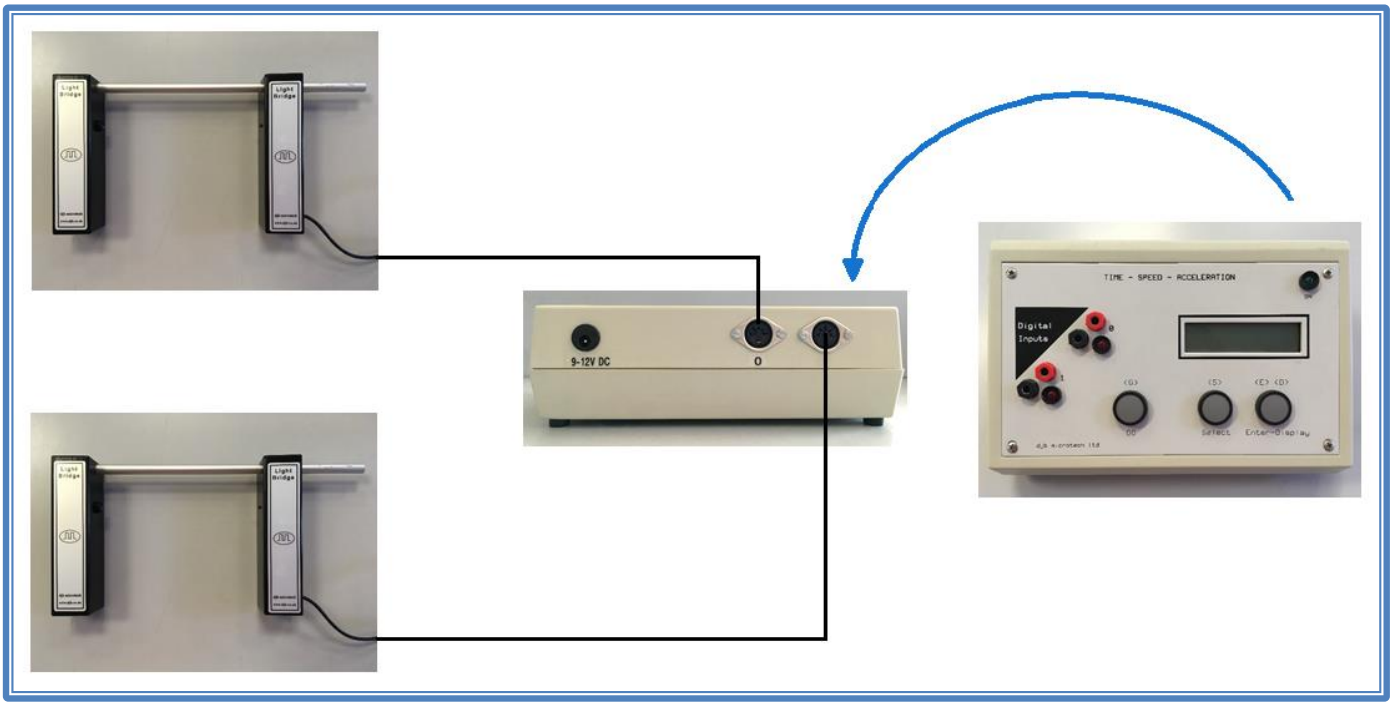
Set up options:



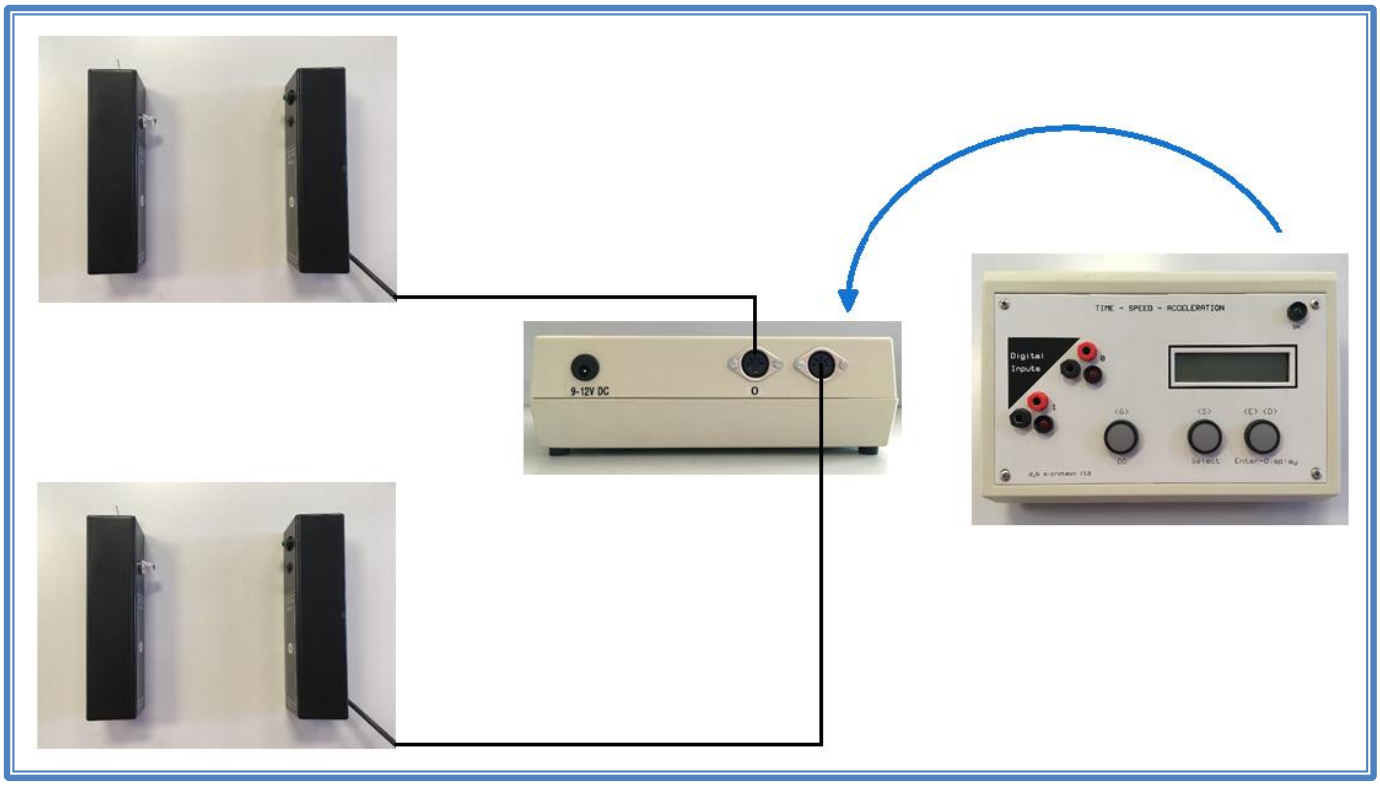


Set up options:





Set up options:



The light gates and bridges can also be used with the new TSA. The connections are all on the side:

Light Gates

Setting up:

When setting the height of the light gates, ensure the trolley and mask are low enough to pass under the gate, but high enough to break the beam.

The light must line up with the receiver. The tables below give information on what to expect from each set up. The light on/off relates to the one on the QED/TSA.

Motion QED

Light gate type	Light on/off when gates lined up	Light on/off when beam broken
Unilab 414.032	On	Off
Unilab 414.033	On	Off

DJB Microtech TSA (OLD)

Light gate type	Light on/off when gates lined up	Light on/off when beam broken
Unilab 414.033	Off	On
DJB Microtech Light Gates*	Off	On
DJB Microtech Light Bridge	On	Off

*There is a green light on the receiver that turns on when the gates are lined up

DJB Microtech TSA (NEW)

Light gate type	Light on/off when gates lined up	Light on/off when beam broken
DJB Microtech Light Gates	Off	On
DJB Microtech Light Bridge	On	Off

Electricity

Series Circuits

Series Circuits

Lamps, cell and Easy-read

Equipment list

Item	Quantity
1.5V cell	1
1.5V lamps	3
Easy-read meters	3
Easy-read shunt (voltmeter)	1
Easy-read shunts (ammeter)	2
Leads	9

Circuit diagrams

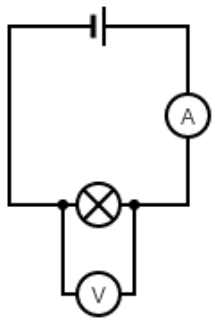
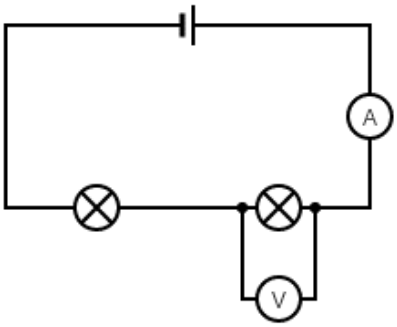
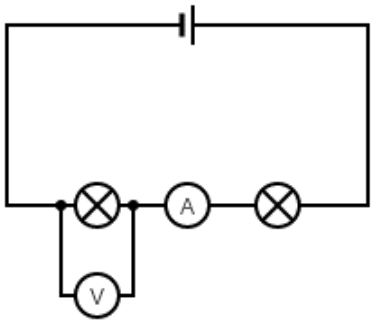
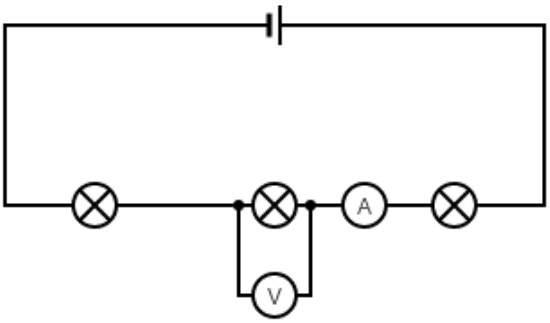
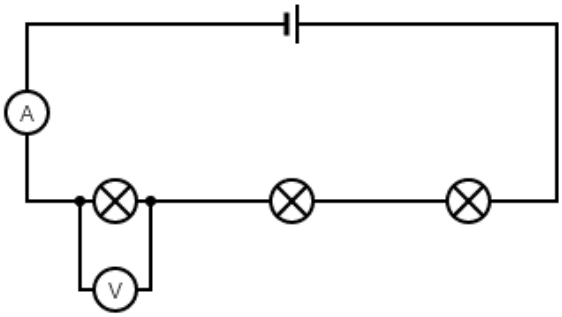
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in series (diagram 2):
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in series (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

Series circuits

Lamps, cell and multimeters

Equipment list

Item	Quantity
1.5V cell	1
1.5V lamps	3
Multimeters (set up as shown)	2
Leads	9

Ammeter:

Voltmeter:

Circuit diagrams

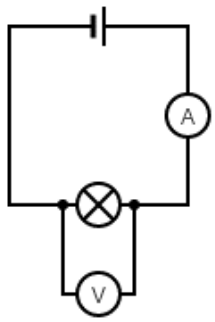
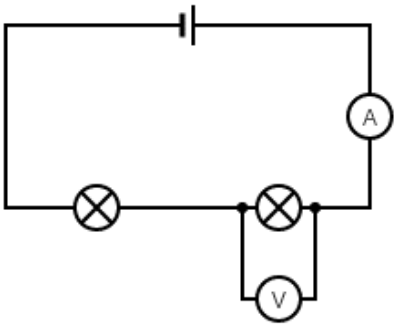
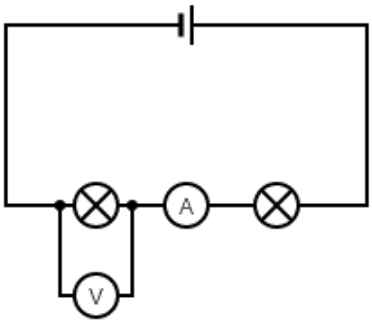
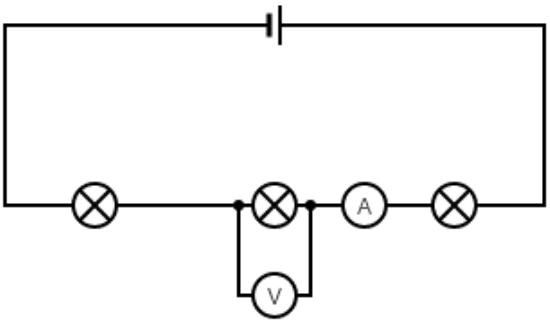
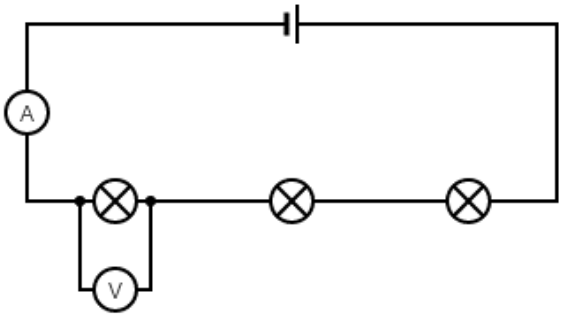
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in series (diagram 2):
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in series (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

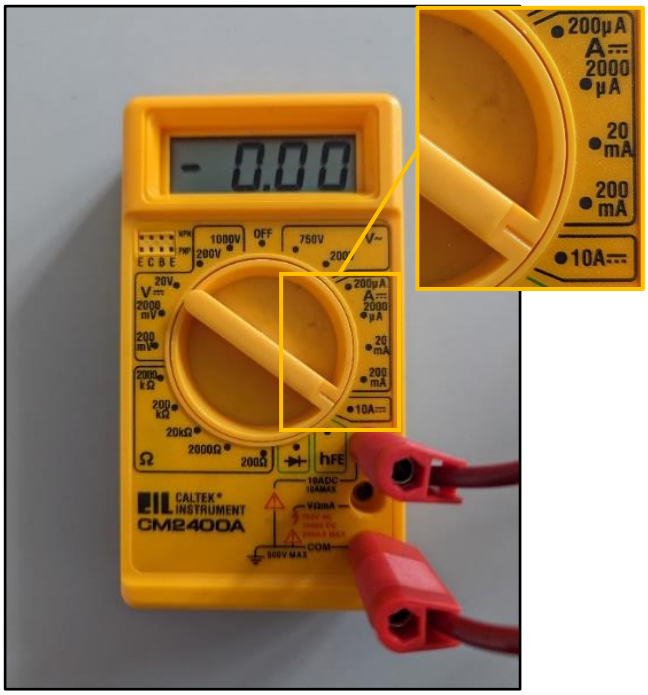
Series circuits

Lamps, PSU and multimeters

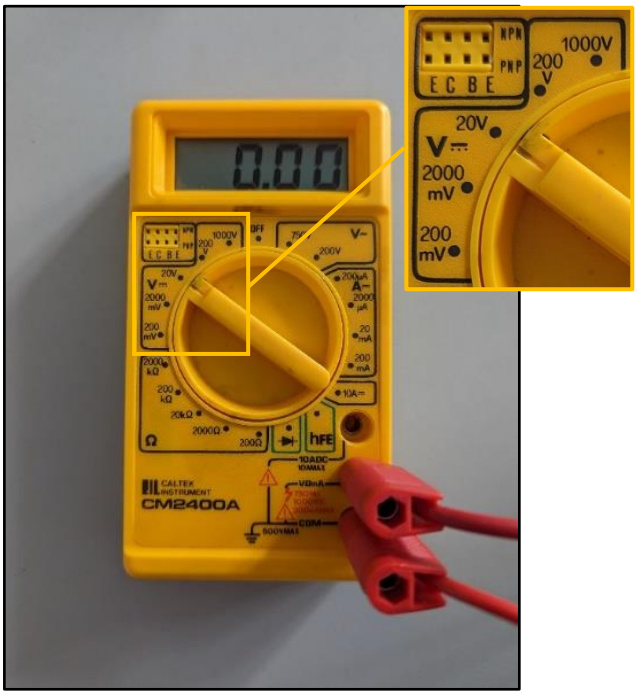
Equipment list

Item	Quantity
12V power pack (set to 6V)	1
6.5V lamps	3
Multimeters (set up as shown)	2
Leads	9

Ammeter:



Voltmeter:



Circuit diagrams

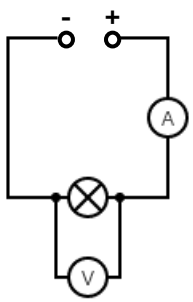
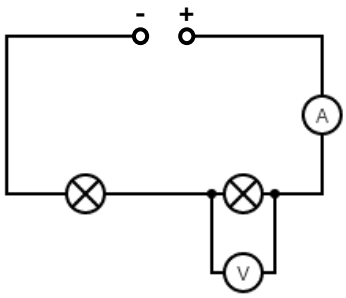
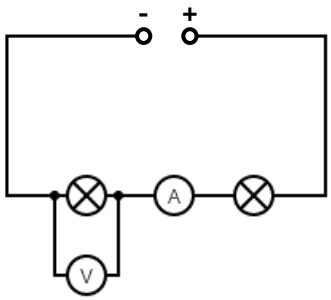
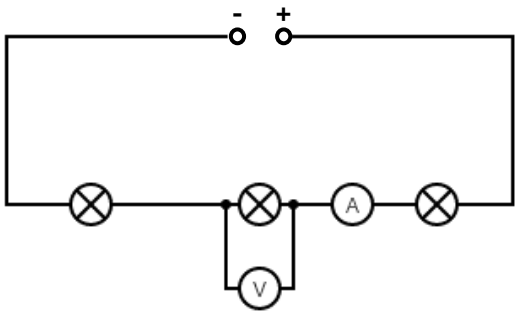
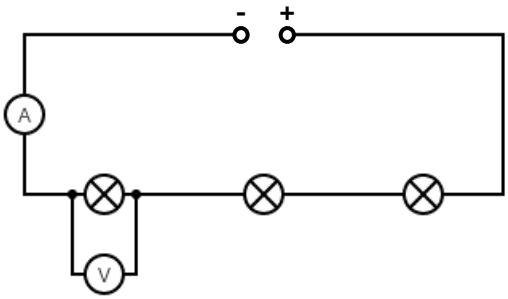
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in series (diagram 2):
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in series (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

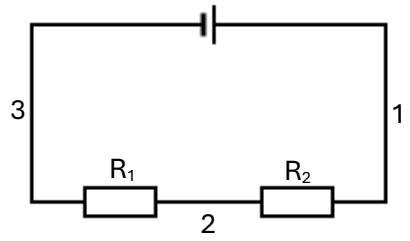
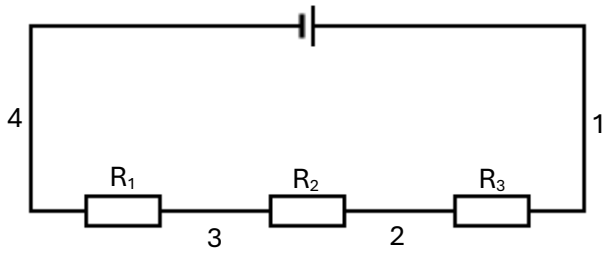
Series circuits

Resistors, cell and Easy-read

Equipment list

Item	Quantity
1.5V cell	1
Resistors (4.7Ω, 7W rated) **(values and ratings are based on max. power output)**	3
Easy-read meters	3
Easy-read shunt (voltmeter)	1
Easy-read shunts (ammeter)	2
Leads	10

Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

1. Set up circuit (diagram 1)
2. Measure V across power supply using voltmeter
3. Repeat for R_1 and R_2
4. Place ammeter(s) in the circuit at positions 1, 2 and 3 and note values
5. Add additional resistor (R_3) in series (diagram 2)
6. Measure V across power supply using voltmeter
7. Repeat for R_1, R_2 and R_3
8. Place ammeter(s) in the circuit at positions 1, 2, 3 and 4 and note values
9. Can be repeated for alternative values of resistor

Series circuits

Resistors, PSU and multimeters

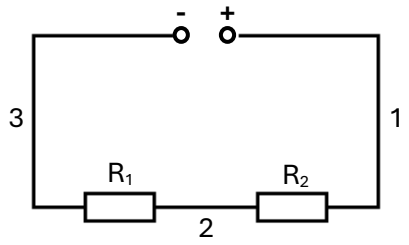
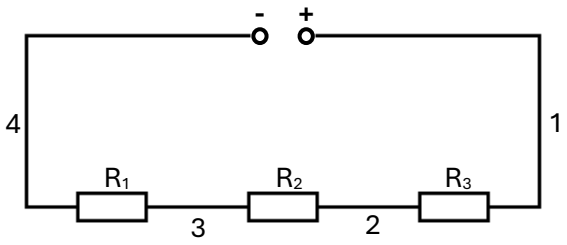
Equipment list

Item	Quantity
12V power pack (set to 10V)	1
Resistors (33Ω, 10W rated) **(values and ratings are based on max. power output)**	3
Multimeters (set up as shown - ammeter x 2, voltmeter x 1)	3
Leads	10

Ammeter:

Voltmeter:

Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

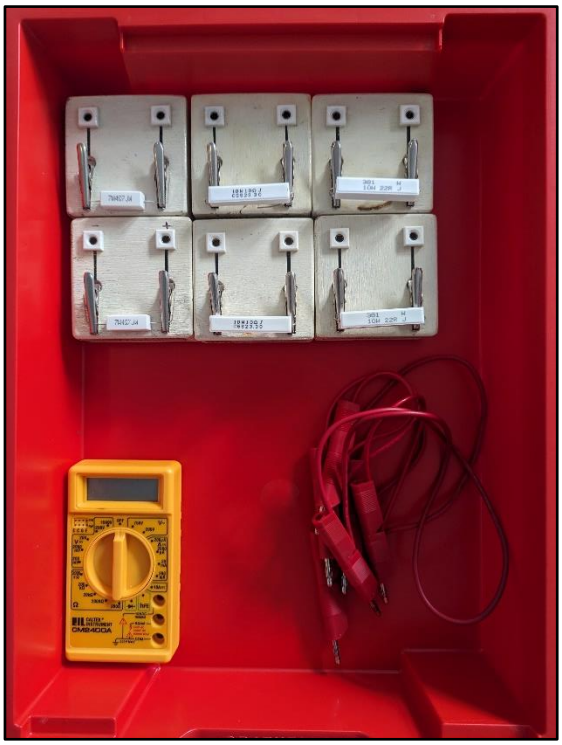
1. Set up circuit (diagram1)
2. Measure V across power supply using voltmeter
3. Repeat for R_1 and R_2
4. Place ammeter(s) in the circuit at positions 1, 2 and 3 and note values
5. Add additional resistor (R_3) in series (diagram 2)
6. Measure V across power supply using voltmeter
7. Repeat for R_1, R_2 and R_3
8. Place ammeter(s) in the circuit at positions 1, 2, 3 and 4 and note values
9. Can be repeated for alternative values of resistor

Series circuits

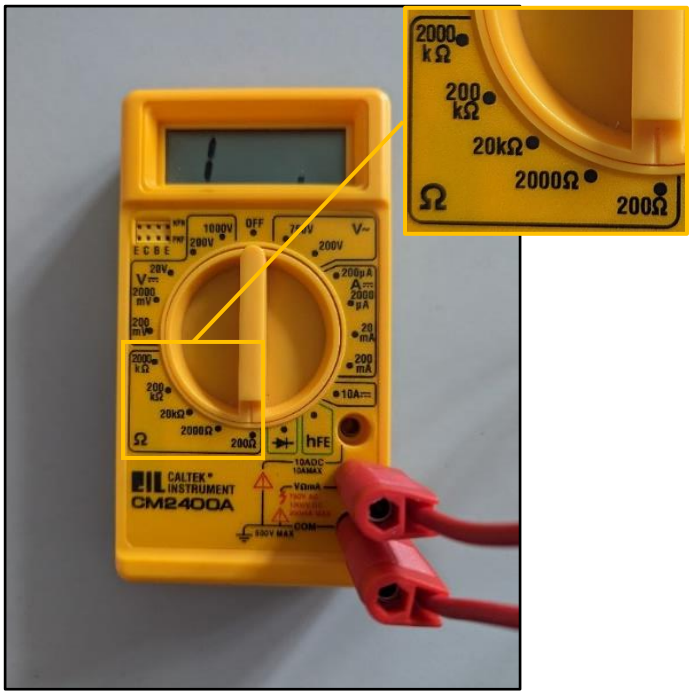
Resistors and multimeter

Equipment list

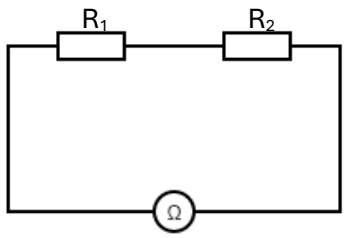
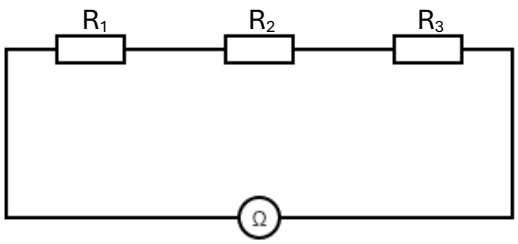
Item	Quantity
Resistors (4.7Ω) **(values and ratings are based on max. power output)**	2
Resistors (10Ω) **(values and ratings are based on max. power output)**	2
Resistors (22Ω) **(values and ratings are based on max. power output)**	2
Multimeter (set up as shown)	1
Leads	6



Ohmmeter:



Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

1. Draw the following table in your workbook

R_1	R_2	R_3	R_T

2. Choose two resistors and set up circuit (diagram 1)
3. Record values for R_1 and R_2 as shown on the resistors
4. Record value for R_T as shown on the ohmmeter
5. Repeat steps 2-4 for 2 other combinations of resistors
6. Now choose three resistors and set up as shown (diagram 2)
7. Record values for R_1, R_2 and R_3 as shown on the resistors
8. Record value for R_T as shown on the ohmmeter
9. Repeat steps 6-9 for 2 other combinations of resistors
10. Work out the relationship

Electricity

Parallel circuits

Parallel Circuits

Lamps, cell and Easy-read

Equipment list

Item	Quantity
1.5V cell	1
1.5V lamps	3
Easy-read meters	3
Easy-read shunt (voltmeter)	1
Easy-read shunts (ammeter)	2
Leads	9

Circuit diagrams

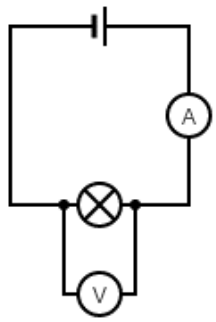
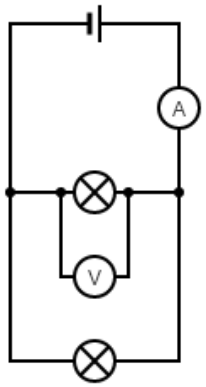
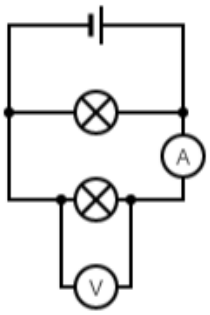
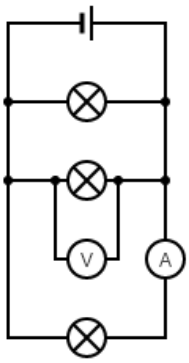
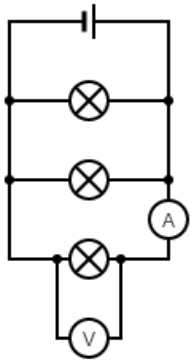
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in parallel (diagram 2)
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in parallel (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

Parallel circuits

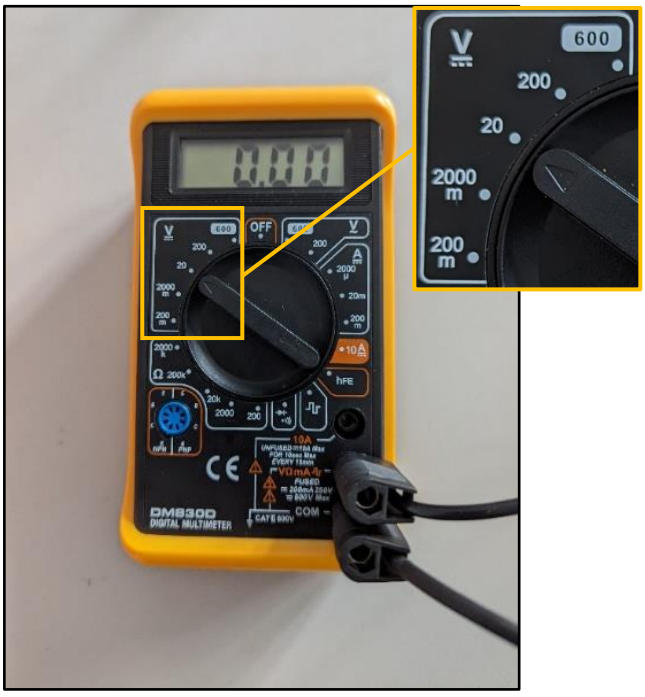
Lamps, cell and multimeters

Equipment list

Item	Quantity
1.5V cell	1
1.5V lamps	3
Multimeters (set up as shown)	2
Leads	9

Ammeter:

Voltmeter:



Circuit diagrams

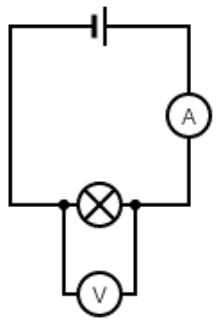
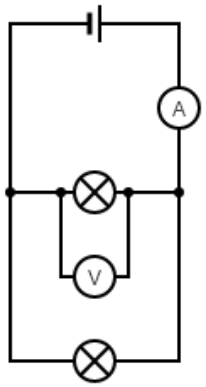
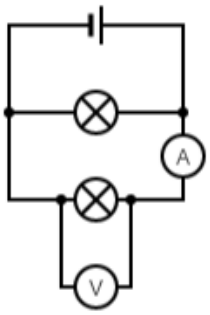
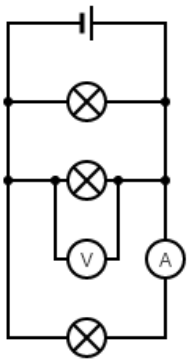
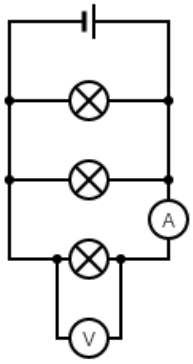
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in parallel (diagram 2)
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in parallel (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

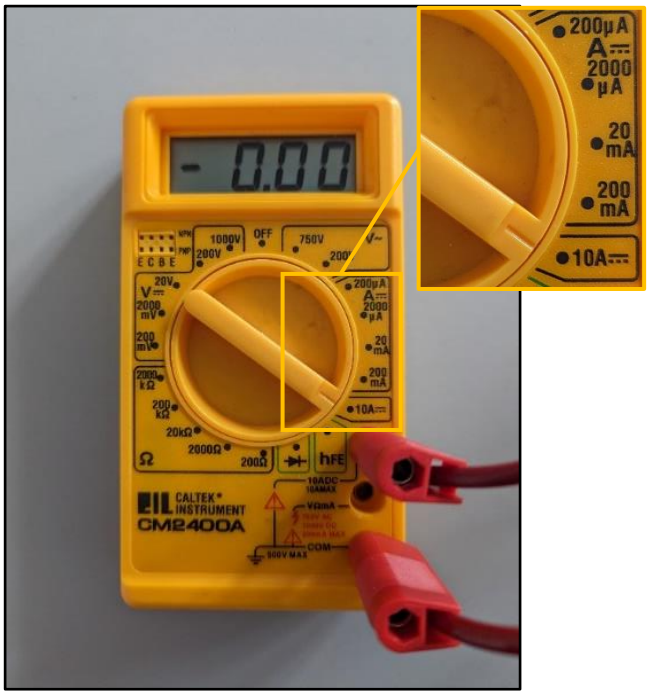
Parallel circuits

Lamps, PSU and multimeters

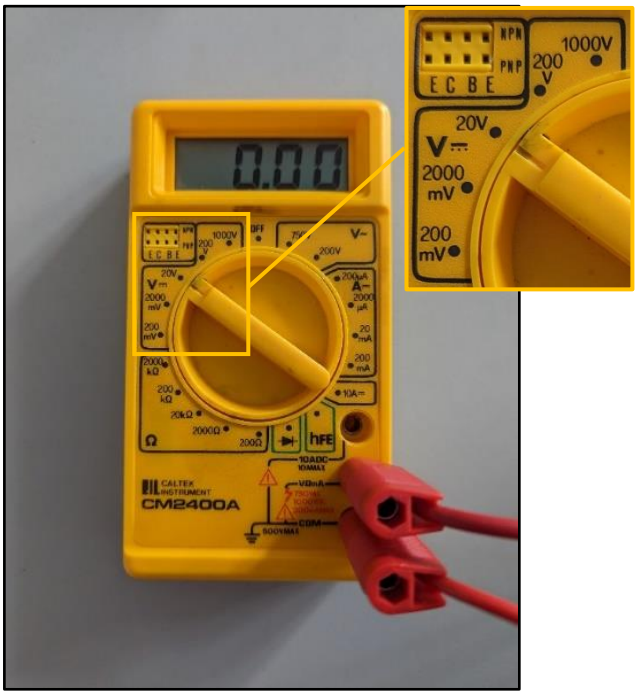
Equipment list

Item	Quantity
12V power pack (set to 6V)	1
6.5V lamps	3
Multimeters (set up as shown)	2
Leads	9

Ammeter:



Voltmeter:



Circuit diagrams

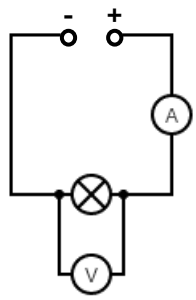
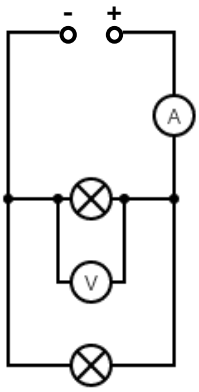
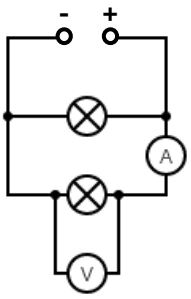
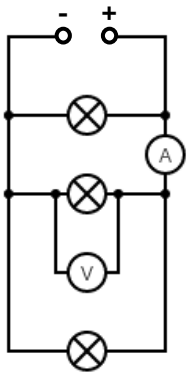
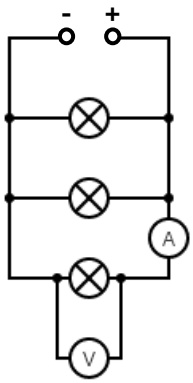
Diagram 1	Diagram 2	Diagram 3
		

Diagram 4	Diagram 5
	

Procedure

1. Set up circuit (diagram 1)
2. Note values of A and V and observe lamp brightness
3. Add additional lamp in parallel (diagram 2)
4. Note values of A and V and observe lamp brightnesses
5. Move meters (diagram 3)
6. Note values of A and V and observe lamp brightnesses
7. Add another lamp in parallel (diagram 4)
8. Note values of A and V and observe lamp brightnesses
9. Move meters (diagram 5)
10. Note values of A and V and observe lamp brightnesses

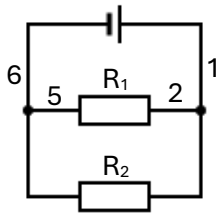
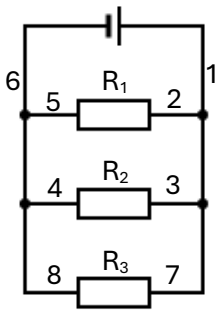
Parallel circuits

Resistors, cell and Easy-read

Equipment list

Item	Quantity
1.5V cell	1
Resistors (4.7Ω, 7W rated) **(values and ratings are based on max. power output)**	3
Easy-read meters	3
Easy-read shunt (voltmeter)	1
Easy-read shunts (ammeter)	2
Leads	10

Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

1. Set up circuit (diagram 1)
2. Measure V across power supply using voltmeter
3. Repeat for R_1 and R_2
4. Place ammeter(s) in the circuit at positions 1, 2, 3, 4, 5 and 6 and note values
5. Add additional resistor (R_3) in series (diagram 2)
6. Measure V across power supply using voltmeter
7. Repeat for R_1, R_2 and R_3
8. Place ammeter(s) in the circuit at positions 1, 2, 3, 4, 5, 6, 7 and 8 and note values
9. Can be repeated for alternative values of resistor

Parallel circuits

Resistors, PSU and multimeters

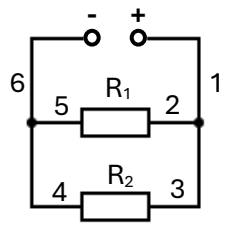
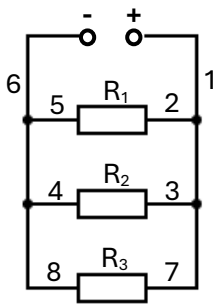
Equipment list

Item	Quantity
12V power pack (set to 10V)	1
Resistors (33Ω, 10W rated) **(values and ratings are based on max. power output)**	3
Multimeters (set up as shown - ammeter x 2, voltmeter x 1)	3
Leads	10

Ammeter:

Voltmeter:

Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

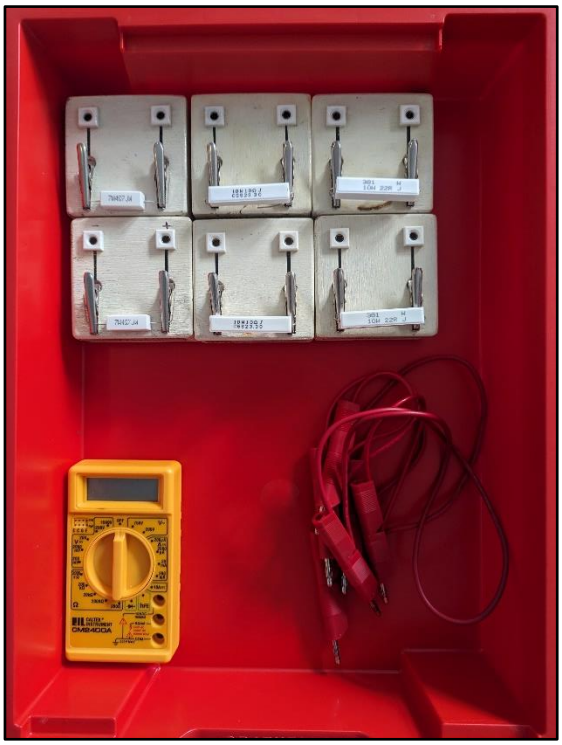
1. Set up circuit (diagram 1)
2. Measure V across power supply using voltmeter
3. Repeat for R_1 and R_2
4. Place ammeter(s) in the circuit at positions 1, 2, 3, 4, 5 and 6 and note values
5. Add additional resistor (R_3) in series (diagram 2)
6. Measure V across power supply using voltmeter
7. Repeat for R_1, R_2 and R_3
8. Place ammeter(s) in the circuit at positions 1, 2, 3, 4, 5, 6, 7 and 8 and note values
9. Can be repeated for alternative values of resistor

Parallel circuits

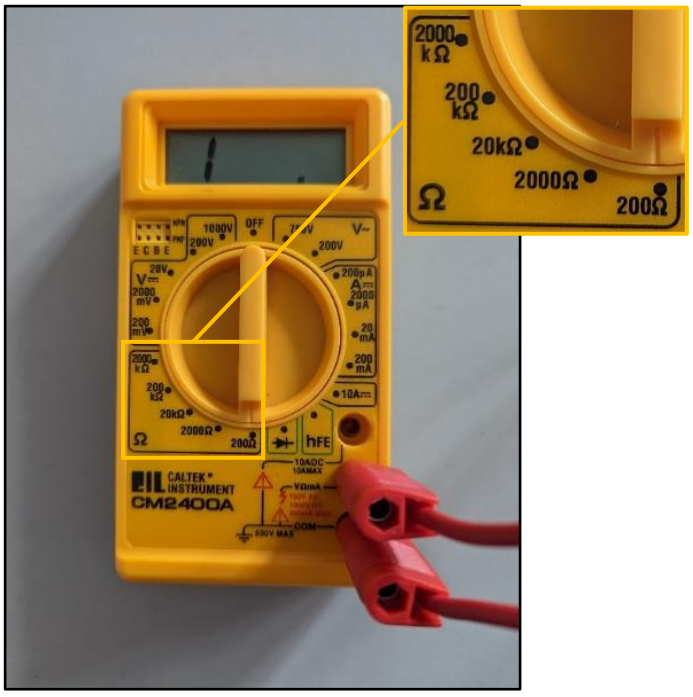
Resistors and multimeter

Equipment list

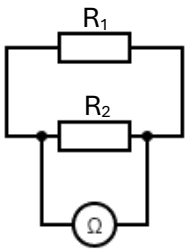
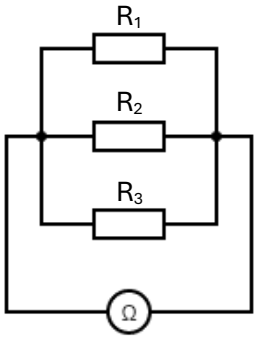
Item	Quantity
Resistors (4.7Ω) **(values and ratings are based on max. power output)**	2
Resistors (10Ω) **(values and ratings are based on max. power output)**	2
Resistors (22Ω) **(values and ratings are based on max. power output)**	2
Multimeter (set up as shown)	1
Leads	6



Ohmmeter:



Circuit diagrams

Diagram 1	Diagram 2
	

Procedure

1. Draw the following table in your workbook

R_1	R_2	R_3	R_T

2. Choose two resistors and set up circuit (diagram 1)
3. Record values for R_1 and R_2 as shown on the resistors
4. Record value for R_T as shown on the ohmmeter
5. Repeat steps 2-4 for 2 other combinations of resistors
6. Now choose three resistors and set up circuit (diagram 2)
7. Record values for R_1, R_2 and R_3 as shown on the resistors
8. Record value for R_T as shown on the ohmmeter
9. Repeat steps 6-9 for 2 other combinations of resistors
10. Draw and fill in the following table in your workbook

$1/R_1$	$1/R_2$	$1/R_3$	$1/R_T$

11. Work out the relationship

Electricity

Ohm’s law

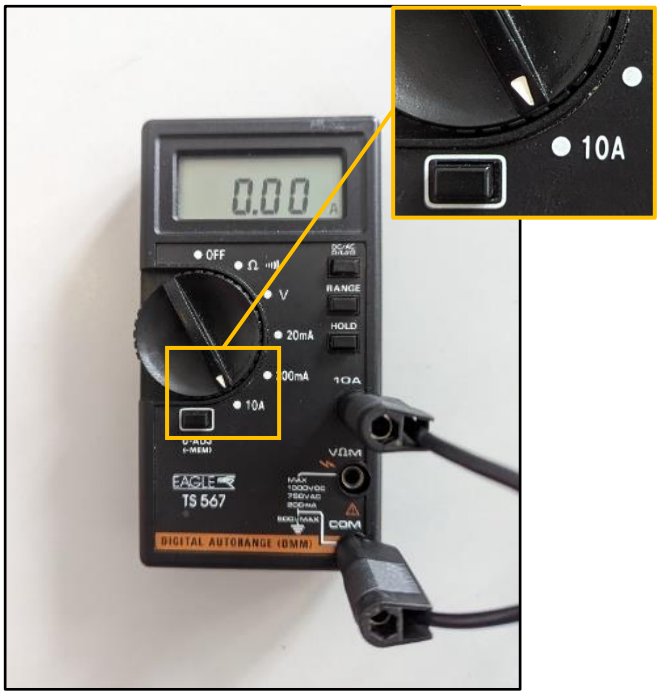
Ohm's Law

Resistor, cells and multimeters

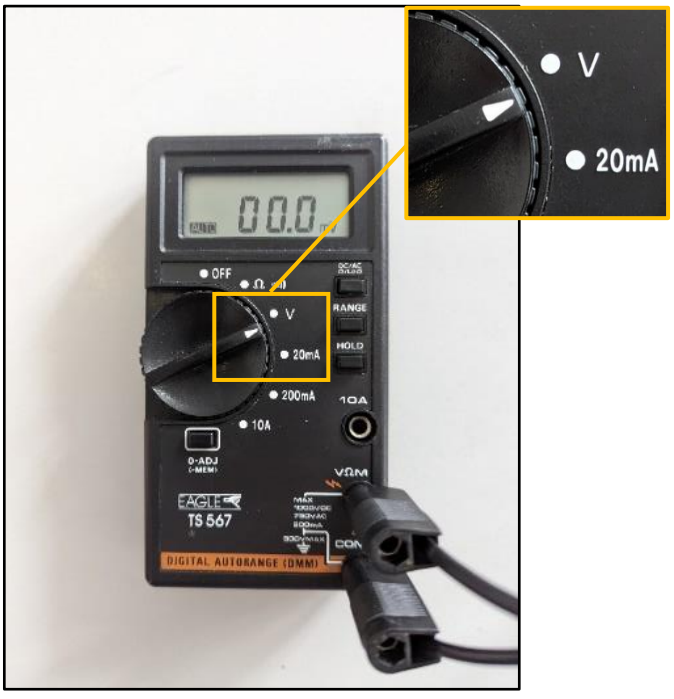
Equipment list

Item	Quantity
1.5V cell	4
Resistor (15Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Multimeters (set up as shown)	2
Leads	8

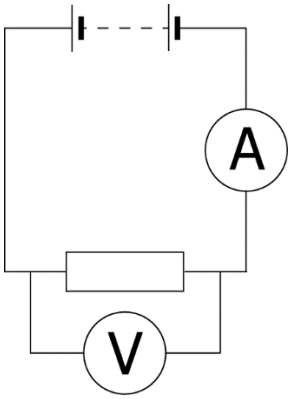
Ammeter:



Voltmeter:



Circuit diagram



Procedure

1. Set up circuit as shown using a single cell [diagram “basic circuit”)
2. Note values of A and V
3. Add additional cell
4. Repeat 2 and 3 until all four cells are included
5. Plot a graph of V against I
6. Draw a line of best fit
7. Calculate the gradient of the line
    a. Select one point near the origin on the line - this will be (x_1, y_1)
    b. Select one point near the top right of the line - this will be (x_2, y_2)
    c. Calculate y_2-y_1
    d. Calculate x_2-x_1
    e. Divide your answer to part c by your answer to part d
    f. The answer to part e is the gradient of the line
8. Compare the gradient of the line to the value of the resistor

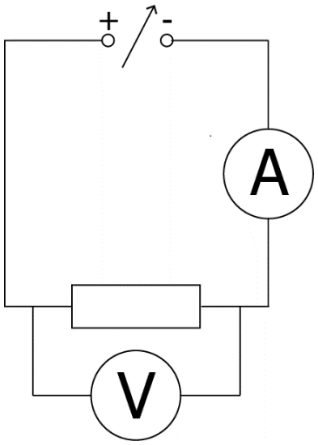
Ohm's law

Resistors, PSU and Easy-read

Equipment list

Item	Quantity
Continuously variable power supply	1
Resistors (15Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Resistors (15Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Resistors (15Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Multimeters	2
Easy-read meters	2
Easy-read shunt (voltmeter)	1
Easy-read shunts (ammeter)	1
Leads	5

Circuit diagram



Procedure

1. Set up circuit as shown [diagram “basic circuit 3”)
2. Alter power supply so the voltmeter reads 1.00V
3. Note values of A and V
4. Repeat for 2, 3, 4, 5, 6, 7, 8, 9 and 10V
5. Plot a graph of V against I
6. Draw a line of best fit
7. Calculate the gradient of the line
    a. Select one point near the origin on the line - this will be (x_1, y_1)
    b. Select one point near the top right of the line - this will be (x_2, y_2)
    c. Calculate y_2-y_1
    d. Calculate x_2-x_1
    e. Divide your answer to part c by your answer to part d
    f. This answer is your gradient
8. Compare the gradient of the line to the value of the resistor
9. This can be repeated for each of the resistors.

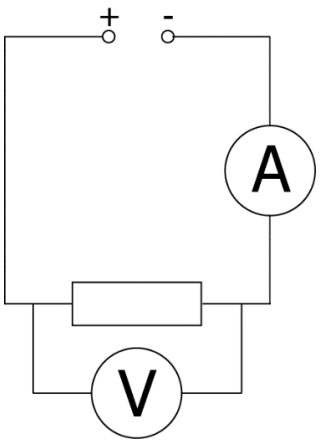
Ohm's law

Resistors, PSU and PASCO meters

Equipment list

Item	Quantity
Power supply	1
Resistors (100Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Resistors (220Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Resistors (330Ω, 10W rated) **(values and ratings are based on max. power output)**	1
Pasco wireless voltage sensor	1
Pasco wireless current sensor	1
Leads	5
SPARKvue (desktop or app)	1

Circuit diagram



Procedure

1. Set up circuit as shown [diagram “basic circuit 3”)
2. Switch on the PASCO ammeter and voltmeter
3. Open SPARKvue on your laptop or phone and set up ohm’s law:
    a. Choose “build new experiment”
    b. Select the first layout option in the top right
    c. Select the image of a line graph (top left of new box at the centre of screen)
    d. Click the Bluetooth sign at the top right
    e. Select to connect to each meter (ensuring the numbers match)
    f. Click periodic (bottom left)
    g. Select manual, click ok
4. Click start on SPARKvue (bottom centre of screen)
5. Adjust the power supply to 0V
6. Switch on the supply
7. Click the tick in the bottom left to take a reading
8. Switch off the supply
9. Adjust the power supply in 1V increments and repeat steps 6-9 until you have adjusted the PSU to all possible values up to 12V.
10. Select stop on SPARKvue
11. Click the option for gradient of line
12. Compare gradient of line to value of resistor
13. This can be repeated for each of the resistors

Dynamics

Average speed

Average speed

Using time between gates (PASCO track with PASCO cart and 2 PASCO wireless smart gates)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO wireless smart gates	2
Laptop or phone with SPARKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first smart gate at 0.9m from bottom of track
3. Place second smart gate at 0.2m from bottom of track
4. Switch on smart gates
5. Open SPARKvue on laptop/phone/phone
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click “1.23” in centre of screen
    d. Select Bluetooth symbol in top right of laptop screen
    e. Both smart gates should appear, click on gate which has the same 6 digit code as the gate at 0.2m
    f. Click cancel
    g. Click on gate which has the same 6 digit code as the gate at 0.9m
    h. Select “smart gate and auxiliary port”
    i. Select “photogate timing (2 photogates)”
    j. Click ok
    k. Ensure flag length matches mask (in this case 0.05m)
    l. Ensure photogate spacing matches distance between gates (in this case 0.7m)
    m. Select “ok”
    n. Select “done”
    o. Top right of screen, click “select measurement”
    p. Select “time between gates”
6. Place cart at 1.0m from bottom of slope
7. Click “start”
8. Release cart ensuring the mask breaks both light gate beams
9. Press “stop” once cart reaches bottom of slope
10. The screen now indicates the time taken to travel between gates
11. The average speed can be calculated by dividing the distance (0.7m) by the time shown
12. Repeat 6-11 as required
13. Repeat 6-12 with altered variables as required
14. Switch off smart gates

Average speed

Precalculated (PASCO track with PASCO cart and 2 PASCO wireless smart gates)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

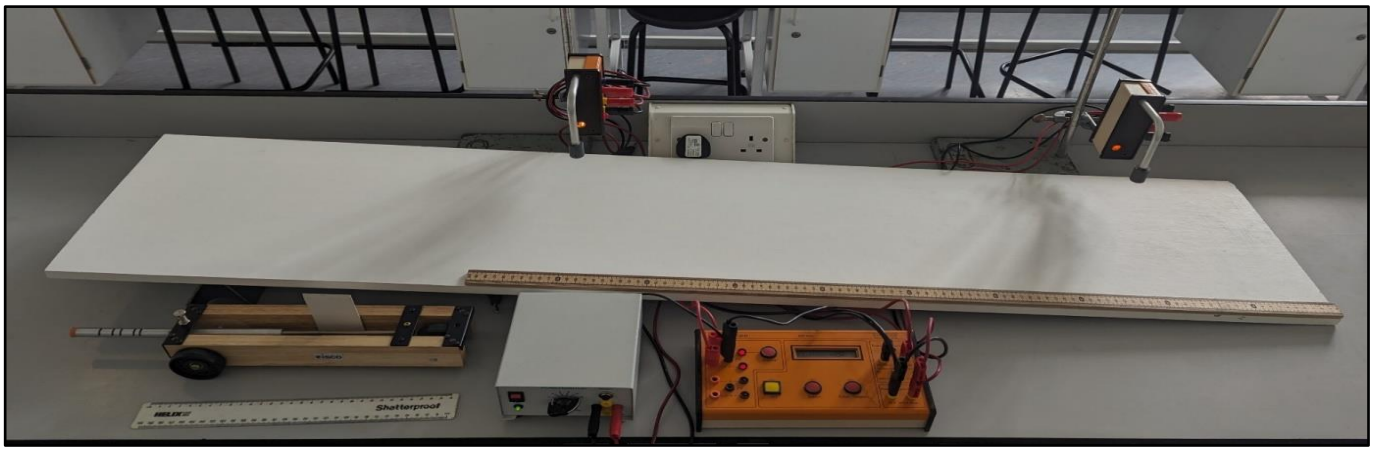
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO wireless smart gates	2
Laptop or phone with SPARKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first smart gate at 0.9m from bottom of track
3. Place second smart gate at 0.2m from bottom of track
4. Switch on smart gates
5. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click “1.23” in centre of screen.
    d. Select Bluetooth symbol in top right of laptop screen
    e. Both smart gates should appear, click on gate which has the same 6 digit code as the gate at 0.2m
    f. Click cancel
    g. Click on gate which has the same 6 digit code as the gate at 0.9m
    h. Select “smart gate and auxiliary port”
    i. Select “photogate timing (2 photogates)”
    j. Click ok
    k. Ensure flaglength matches mask (in this case 0.05m)
    l. Ensure photogate spacing matches distance between gates (in this case 0.7m)
    m. Select “ok”
    n. Select “done”
    o. Top right of screen, click “select measurement”
    p. Select “velocity between gates”
6. Place cart at 1.0m from bottom of slope
7. Click “start”
8. Release cart ensuring the mask breaks both light gate beams
9. Press stop once cart reaches bottom of slope
10. The screen now indicates the average speed of the cart between gates
11. Repeat 6-10 as required
12. Repeat 6-11 with altered variables as required
13. Switch off smart gates

Average speed

Using time between gates (Basic slope with simple cart and QED with 2 light gates)



Equipment list

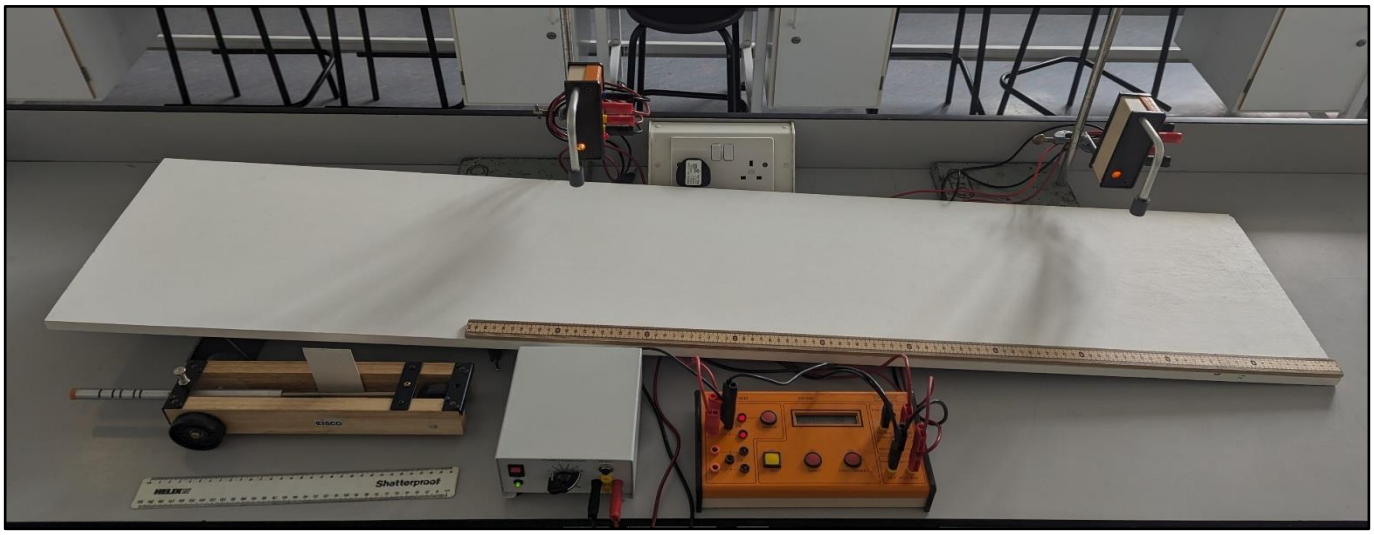
Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Cart with 0.05m mask	1
Metre stick	1
Ruler	1
Light gates	2
Long leads	10
Clamp stands with boss head	2

Procedure

1. Set up equipment as shown ensuring wires are out of the way
2. Lay meter stick on slope
3. Place light gates on clamp stands at 0.2m and 0.9m from bottom of slope
4. Connect 0.9m light gate to port 1
5. Connect 0.2m light gate to port 2
6. Press select until display shows “gap time”, press enter
7. Press select
8. Press enter to accept 1 reading
9. Place cart at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
10. Press go
11. Release cart
12. Read time between gates
13. Calculate speed using 0.7m/time on QED
14. Press enter
15. Repeat 9-14 as required
16. Repeat 9-15 for different release heights/distances between gates/slope heights

Average speed

Precalculated (Basic slope with simple cart and QED with 2 light gates)



Equipment list

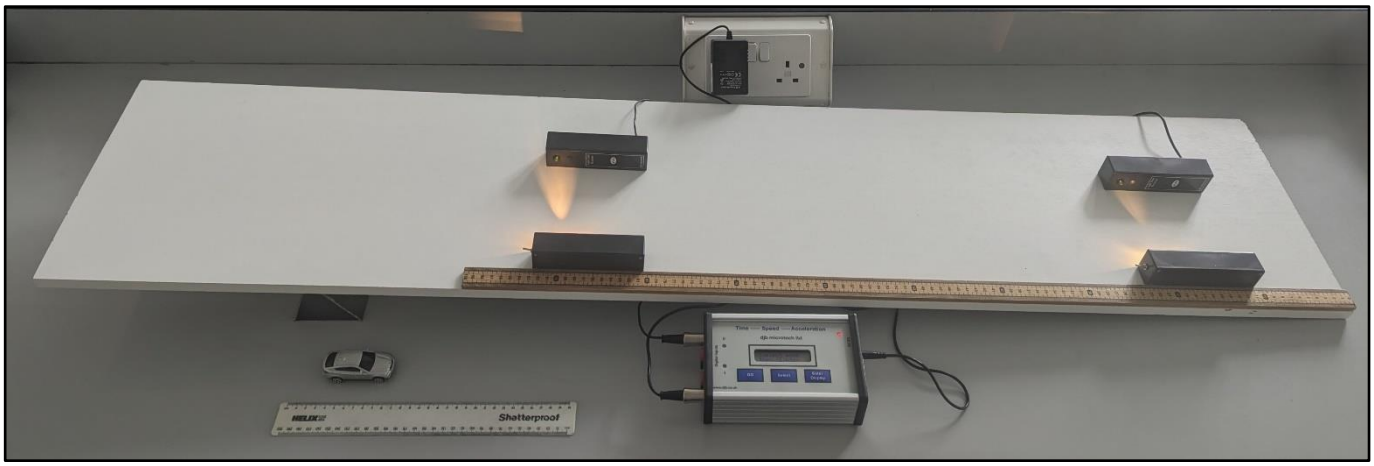
Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Cart with 0.05m mask	1
Metre stick	1
Ruler	1
Light gates	2
Long leads	10
Clamp stands with boss head	2

Procedure

1. Setup equipment as shown ensuring wires are out of the way.
2. Lay meter stick on slope.
3. Place light gates on clamp stands at 0.2m and 0.9m from bottom of slope
4. Connect 0.9m light gate to port 1
5. Connect 0.2m light gate to port 2
6. Press select until display shows “average speed”, press enter
7. Press select until display shows 70 (note that above 10 it goes up in 10s) for 0.7m between gates, press enter
8. Place cart at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
9. Press go
10. Release cart
11. Read average speed on QED
12. Repeat 8-11 as required
13. Repeat 8-12 for different release heights/distances between gates/slope heights

Average speed

Using time between gates (Basic slope with car and TSA with 2 light gates positioned horizontally)



Equipment list

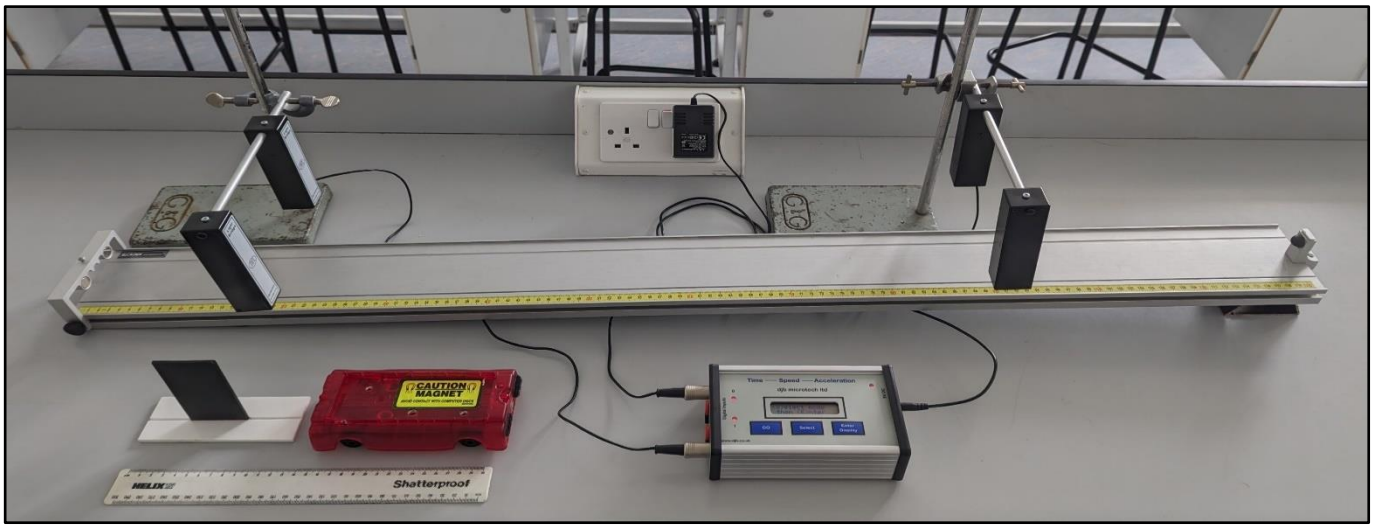
Item	Quantity
Sheet of wood for slope	1
TSA	1
Car with 0.05m mask	1
Metre stick	1
Ruler	1
Light gates (light source and receiver)	2

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Place light gates at 0.2m and 0.9m from bottom of slope
4. Connect 0.9m light gate to port 0.
5. Connect 0.2m light gate to port 1
6. Switch on light gates and check alignment between source and receiver (green light will show on receiver)
7. Press select until display shows “gap time”, press enter
8. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates.
9. Press go
10. Release car
11. Read time between gates
12. Calculate speed using 0.7m/time on TSA
13. Repeat 8-12 as required
14. Repeat 8-13 for different release heights/distances between gates/slope heights

Average speed

Using time between gates (PASCO track with PASCO cart and TSA with 2 light bridges)



NB This can be completed with light gates but you may require 2 further clamp stands.

Equipment list

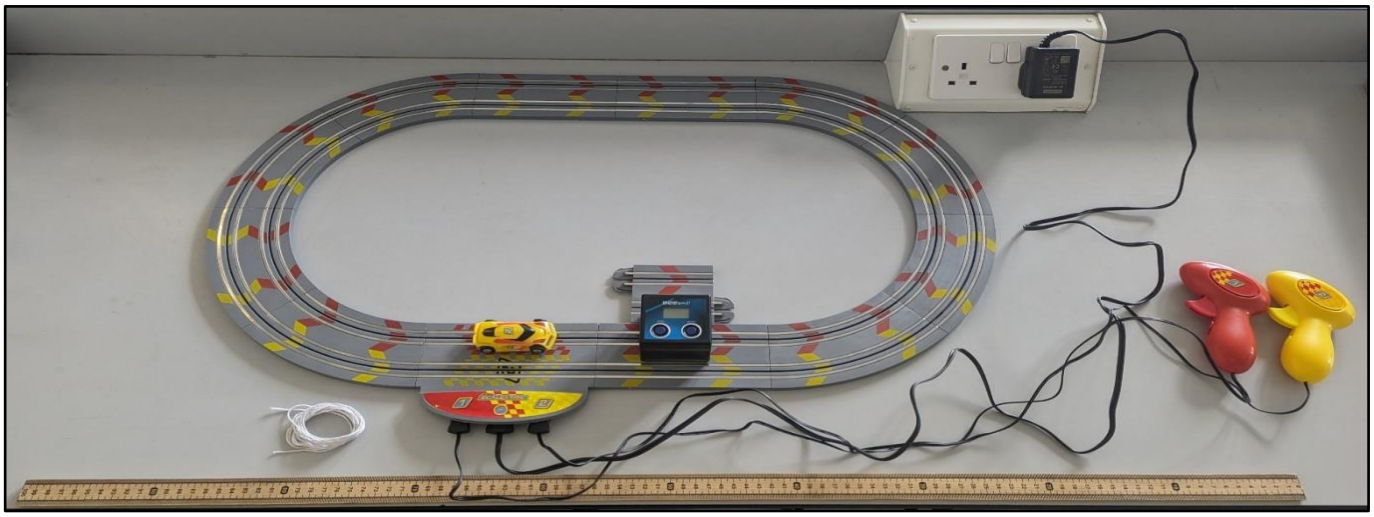
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
TSA	1
Light bridges	2
Clamp stands with boss head	2
Ruler	1

Procedure

1. Set up equipment as shown
2. Place light bridges on clamp stands at 0.2m and 0.9m from bottom of slope
3. Connect 0.9m light bridge to port 0
4. Connect 0.2m light bridge to port 1
5. Press select until display shows “gap time”
6. Press enter
7. Place cart at 1.0m from bottom of slope, ensuring it will cut the light bridge beams
8. Press go
9. Release cart
10. Read time between gates
11. Calculate speed using 0.7m/time on TSA
12. Repeat 7-11 as required
13. Repeat 7-12 for different release heights/distances between gates/slope heights

Average speed

Scalextric with 1 BeeSpiV



Equipment list

Item	Quantity
Scalextric track	1
Scalextric car	1
Scalextric controller	1
String	1
Metre stick	1
BeeSpiV	1

Procedure

1. Set up track as shown without connecting the power
2. Use the string to measure the inside and the outside tracks
3. Connect the track to the power
4. Place the BeeSpiV across the inside track using a spare piece of track for balance, and ensure the car can pass freely through the BeeSpiV
5. Ensure both controllers are set to the same setting
6. Press start on BeeSpiV to switch it on
7. Ensure BeeSpiV has “sec” displayed at the right hand side of the display. If ‘m/s’, ‘km/h’ or ‘cm/s’ are displayed, hold the start button.
8. Place the car at entrance of the BeeSpiV
9. Press ‘start’
10. Use the controller to make the Scalextric car move round the circuit and through the BeeSpiV 5 times then stop
11. The reading shown is the time in seconds to complete the lap 5 laps, by pressing the select button you can see the times for 5,4,3,2 and 1 lap respectively
12. Calculate the time for each individual lap (the first lap should be discounted as the speed will differ significantly)
13. Divide the distance of the track/the time taken for the lap to get average speed for each lap
14. Repeat 8-13 placing the BeeSpiV and the car on the outer ring

Average speed

Basic slope and car with timer

Equipment list

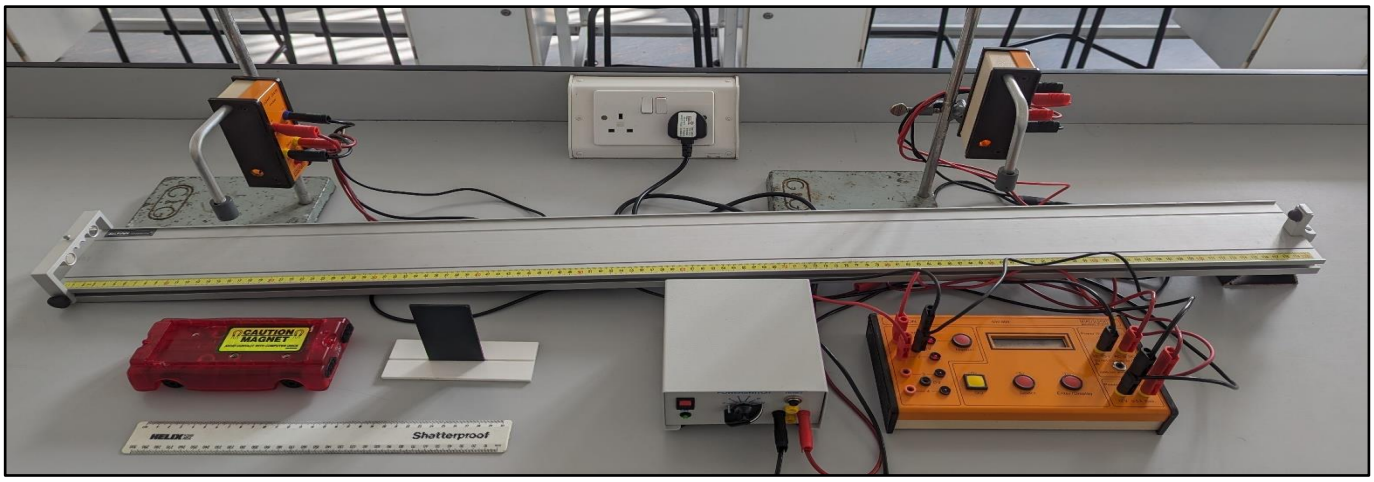
Item	Quantity
Sheet of wood for slope	1
Timer or stopwatch	1
Metre stick	1
Car	1

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Choose point to release cart
4. Release car and start timer simultaneously
5. Stop timer when car reaches bottom of the slope
6. Calculate average speed by dividing total time by distance travelled
7. Repeat as necessary
8. Repeat 3-7 for different points on slope or different angles of slope

Average speed

Using time between gates (PASCO track and PASCO cart and QED with 2 light gates)



Equipment list

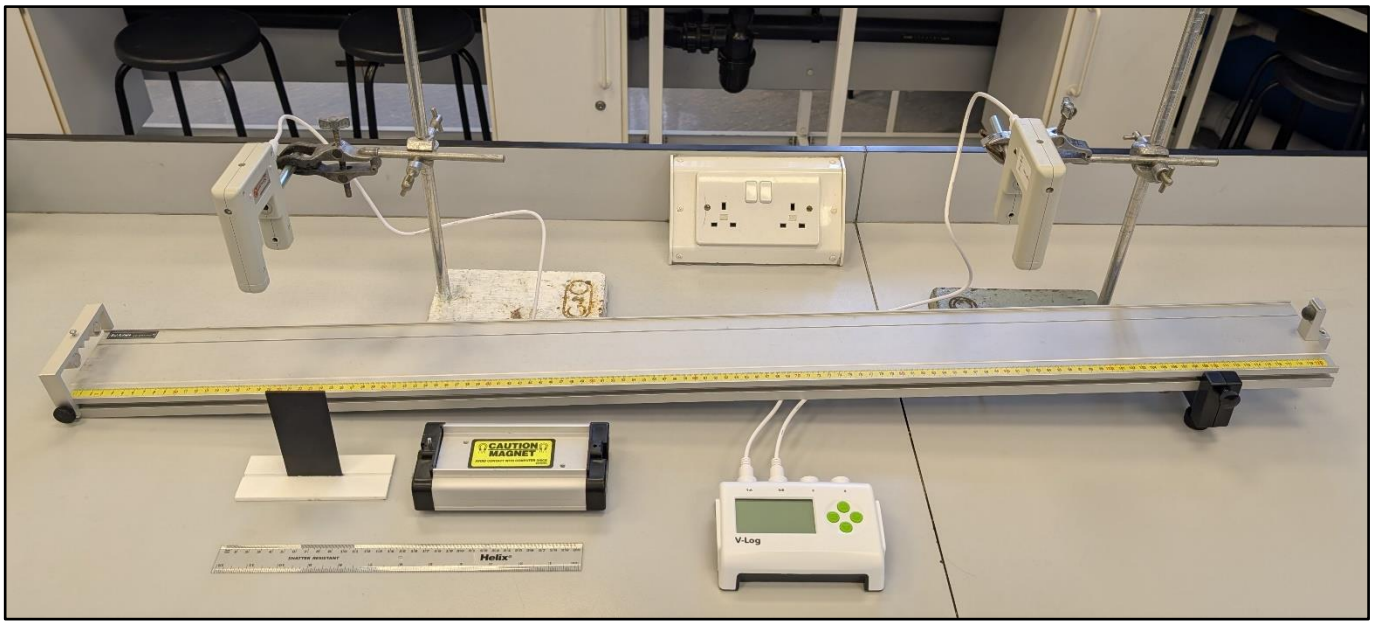
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
QED	1
Power pack (12V)	1
Long leads	10
Light gates	2
Clamp stands with boss head	2
Ruler	1

Procedure

1. Set up track as shown
2. Place light gates on clamp stands at 0.2m and 0.9m from bottom of slope
3. Connect 0.9m light gate to port 1
4. Connect 0.2m light gate to port 2
5. Press select until display shows “gap time”
6. Press enter
7. Press select
8. Press enter to accept 1 reading
9. Place cart at 1.0m from bottom of slope ensuring mask will cut light gate beams
10. Press go
11. Release cart
12. Read time between gates
13. Calculate speed using 0.7m/time on QED.
14. Press enter
15. Repeat 9-14 as required
16. Repeat 9-15 for different release heights/distances between gates/slope heights.

Average speed

Using time between gates (PASCO track with PASCO cart, 2 Data Harvest light gates and Data Harvest V-Log4 data logger)



Equipment list

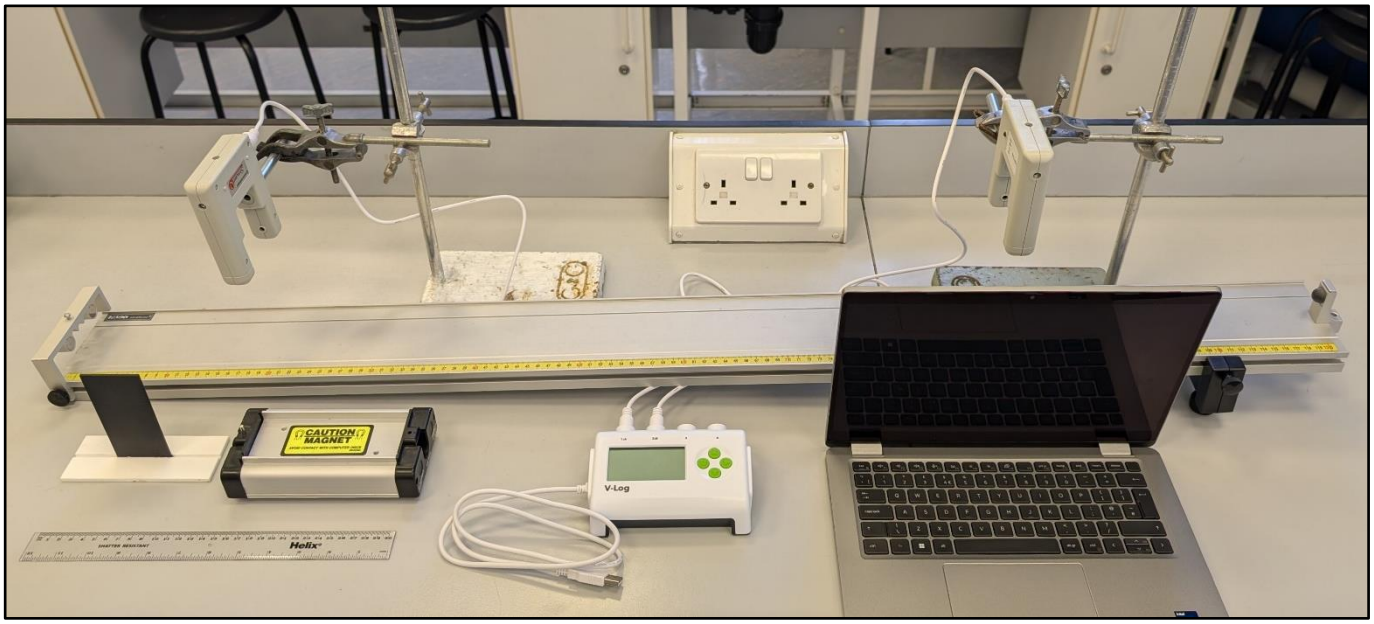
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Time”
    c. Select “Time from A to B”
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks both light gate beams
7. The data logger screen now indicates the time taken to travel between gates (take the top number)
8. The average speed can be calculated by dividing the distance (0.7m) by the time shown.
9. Repeat 5-8 as required (each new reading will replace the previous one)
10. After 3 runs, the bottom number gives the average time to travel between gates. This can also be used to calculate average speed.
11. Return to the home screen by pressing the green stop button, then the right button
12. Repeat 4-11 with altered variables as required

Average speed

Using time between gates (PASCO track with PASCO cart, 2 Data Harvest light gates, Data Harvest V-Log4 data logger and laptop/phone)



Equipment list

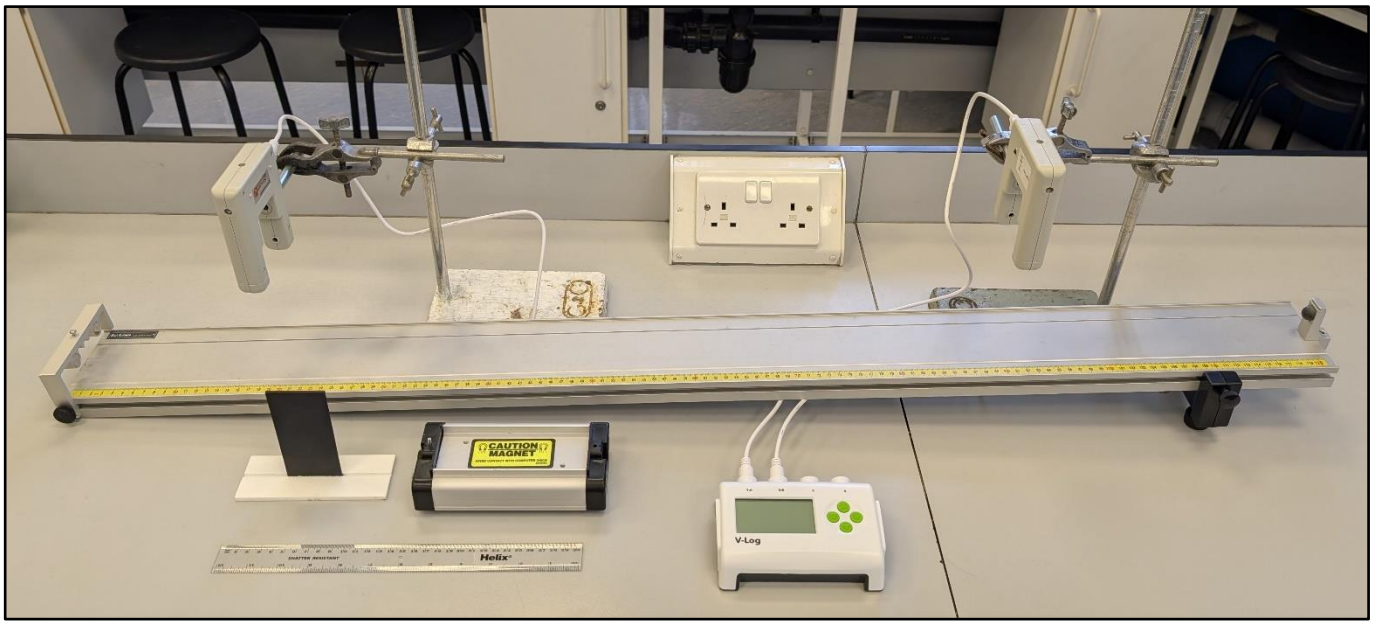
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
5. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Change “Where?” to “From A to B”
    g. Close window
    h. Click “Start” (under graph)
6. Place cart at 1.0m from bottom of slope
7. Release cart ensuring the mask breaks both light gate beams
8. The laptop/phone screen now indicates the time taken to travel between gates
9. The average speed can be calculated by dividing the distance (0.7m) by the time shown.
10. Repeat 6-9 as required (each new reading will be recorded in sequence)
11. Repeat 6-10 with altered variables as required

Average speed

Precalculated (PASCO track with PASCO cart, 2 Data Harvest light gates and Data Harvest V-Log4 data logger)



Equipment list

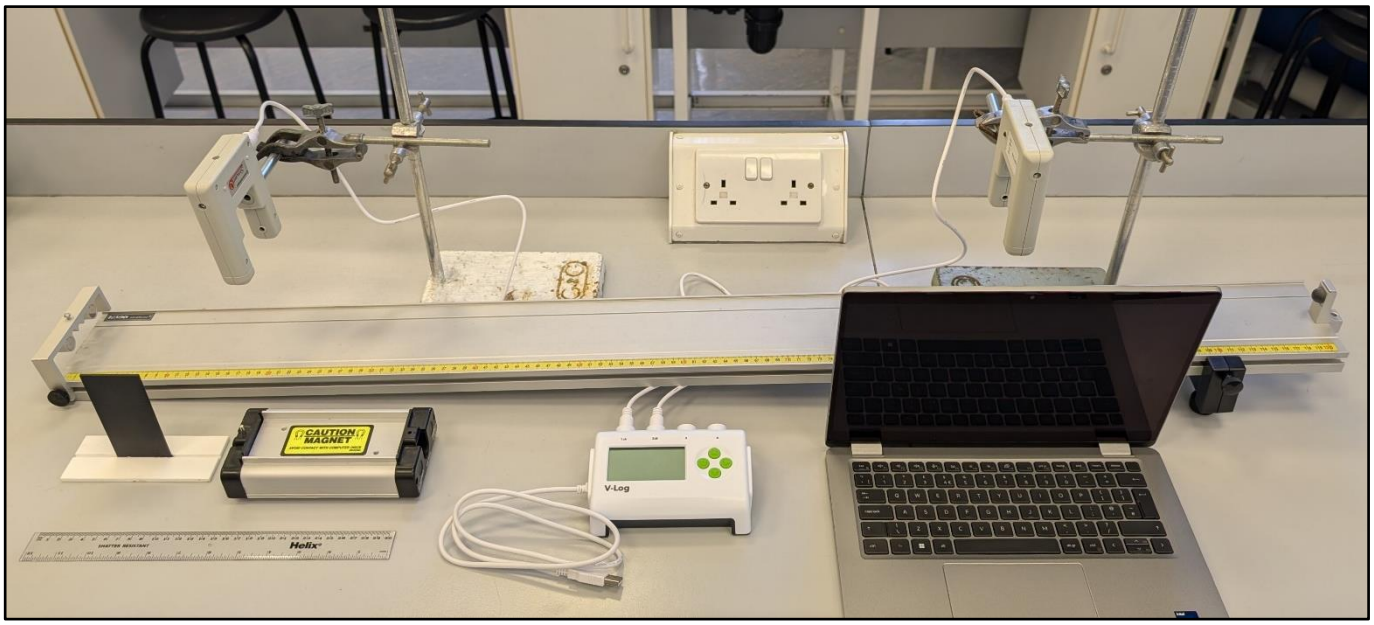
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Speed”
    c. Select “Speed from A to B”
    d. Select “Distance A to B” then change to 700mm
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks both light gate beams
7. The data logger screen now indicates the average speed of the cart between gates (take the top number)
8. The average speed can be calculated by dividing the distance (0.7m) by the time shown.
9. Repeat 5-8 as required (each new reading will replace the previous one)
10. After 3 runs, the bottom number gives the average speed between gates
11. Return to the home screen by pressing the green stop button, then the right button
12. Repeat 4-11 with altered variables as required

Average speed

Precalculated (PASCO track with PASCO cart, 2 Data Harvest light gates, Data Harvest V-Log4 data logger and laptop/phone)



Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
5. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Change “Timing Mode” to “Speed/Velocity”
    g. Change “Where?” to “From A to B”
    h. Change “Distance A to B” to 0.7m
    i. Close window
    j. Click “Start” (under graph)
6. Place cart at 1.0m from bottom of slope
7. Release cart ensuring the mask breaks both light gate beams
8. The laptop/phone screen now indicates the average speed between gates
9. Repeat 6-8 as required (each new reading will be recorded in sequence)
10. Repeat 6-9 with altered variables as required

Dynamics

Instantaneous speed

Instantaneous speed

Using time in gate (PASCO track with PASCO cart, 1 PASCO wireless smart gate and laptop/phone)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO smart gate	1
Ruler	1
Laptop or phone with SPARKvue installed	1

Procedure

1. Set up equipment as shown
2. Place smart gate at 0.9m from bottom of track
3. Switch on smart gate
4. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click “1.23” in centre of screen.
    d. Select Bluetooth symbol in top right of laptop screen
    e. Click on gate which has the same 6 digit code as the gate at 0.9m
    f. Select “smart gate only”
    g. Select “photogate timing (1 photogate)”
    h. Click ok
    i. Ensure flaglength matches mask (in this case 0.05m)
    j. Select “ok”
    k. Select “done”
    l. Top right of screen, click “select measurement”
    m. Select “time in gate”
5. Place cart at 1.0m from bottom of slope
6. Click “start”
7. Release cart ensuring the mask breaks the light gate beam
8. Press stop once cart reaches bottom of slope
9. The screen now indicates the time taken to pass through the gate
10. Calculate speed using 0.05m/time on screen
11. Repeat 5-10 as required
12. Repeat 5-11 with altered variables as required
13. Switch off smart gate

Instantaneous speed

Precalculated (PASCO track with PASCO cart, 1 PASCO wireless smart gate and laptop/phone)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

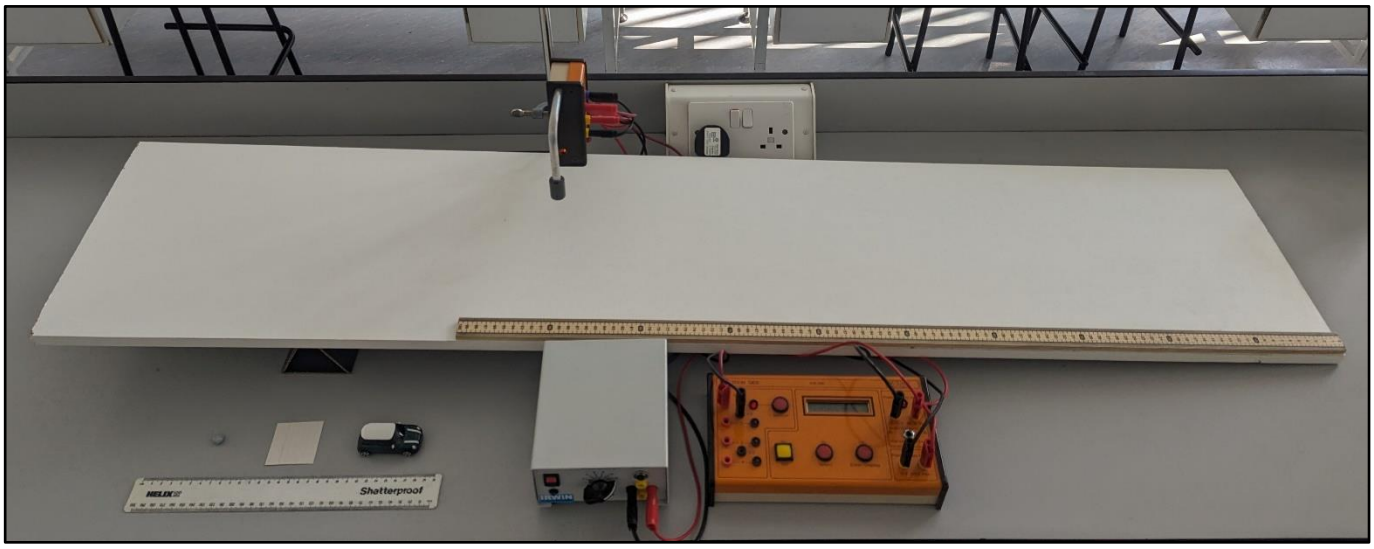
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO smart gate	1
Ruler	1
Laptop or phone with SPARKvue installed	1

Procedure

1. Set up equipment as shown
2. Place smart gate at 0.9m from bottom of track
3. Switch on smart gate
4. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click “1.23” in centre of screen.
    d. Select Bluetooth symbol in top right of laptop screen
    e. Click on gate which has the same 6 digit code as the gate at 0.9m
    f. Select “smart gate only”
    g. Select “photogate timing (1 photogate)”
    h. Click ok
    i. Ensure flaglength matches mask (in this case 0.05m)
    j. Select “ok”
    k. Select “done”
    l. Top right of screen, click “select measurement”
    m. Select “velocity in gate”
5. Place cart at 1.0m from bottom of slope
6. Click “start”
7. Release cart ensuring the mask breaks the light gate beam
8. Press stop once cart reaches bottom of slope
9. The screen now indicates the speed of the cart in the gate
10. Repeat 5-9 as required
11. Repeat 5-10 with altered variables as required
12. Switch off smart gate

Instantaneous speed

Precalculated (Basic slope with car and QED with 1 light gate)



Equipment list

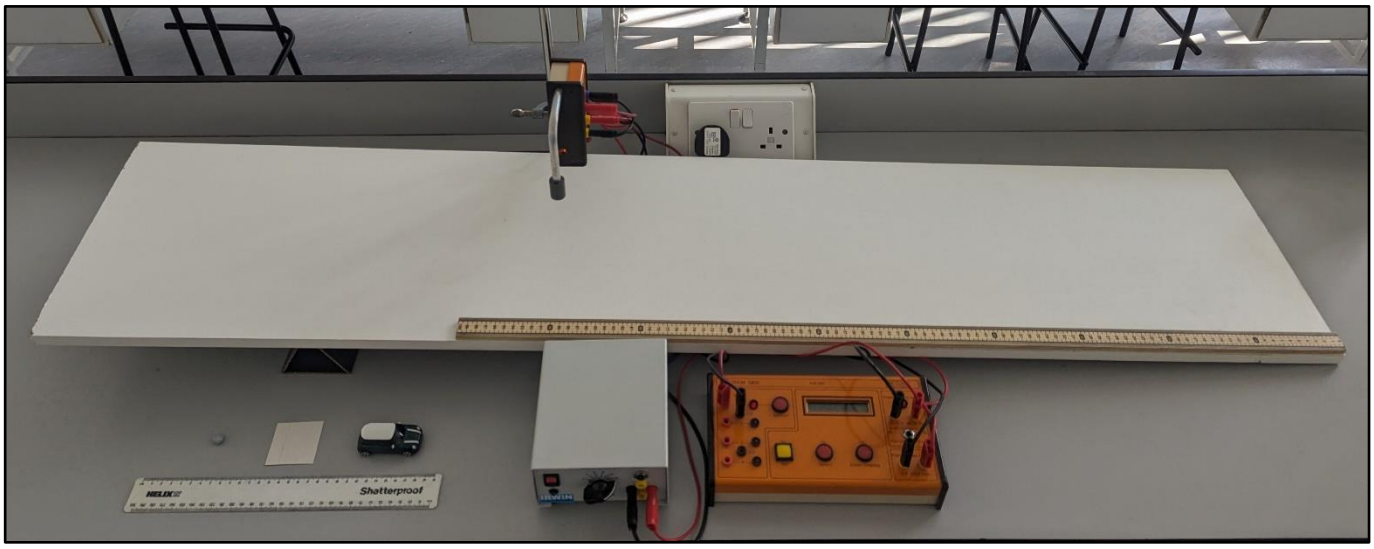
Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Car with 0.05m mask (attach to top)	1
Metre stick	1
Ruler	1
Light gate	1
Long leads	6
Clamp stand with boss head	1

Procedure

1. Setup equipment as shown ensuring wires are out of the way
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Connect light gate to port 1
5. Press select until display shows “speed”, press enter
6. Press select
7. Press enter to accept for 1 reading
8. Press select until display shows “5” for 0.05m mask, press enter
9. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gate
10. Press go
11. Release car
12. Read speed from QED
13. Repeat 9-12 as required
14. Repeat 9-13 for different release heights/positions of gate/slope heights

Instantaneous speed

Using time in gate (Basic slope with car and QED with 1 light gate)



Equipment list

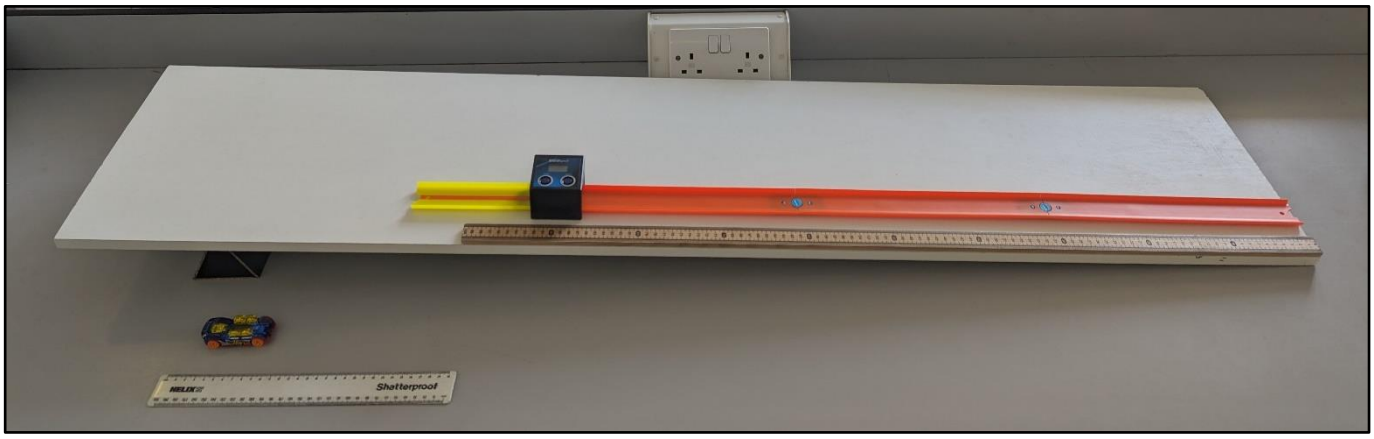
Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Car with 0.05m mask (attach to top)	1
Metre stick	1
Ruler	1
Light gate	1
Long leads	6
Clamp stand with boss head	1

Procedure

1. Set up equipment as shown ensuring wires are out of the way
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Connect light gate to port 1
5. Press select until display shows “time interval”, press enter
6. Press select
7. Press enter to accept 1 reading
8. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gate
9. Press go
10. Release car
11. Read time the mask takes to pass through the gate
12. Calculate speed using 0.05m/time on QED
13. Repeat 8-12 as required
14. Repeat 8-13 for different release heights/position of gate/slope heights

Instantaneous speed

Basic slope with hot wheels track and 1 BeeSpiV



Equipment list

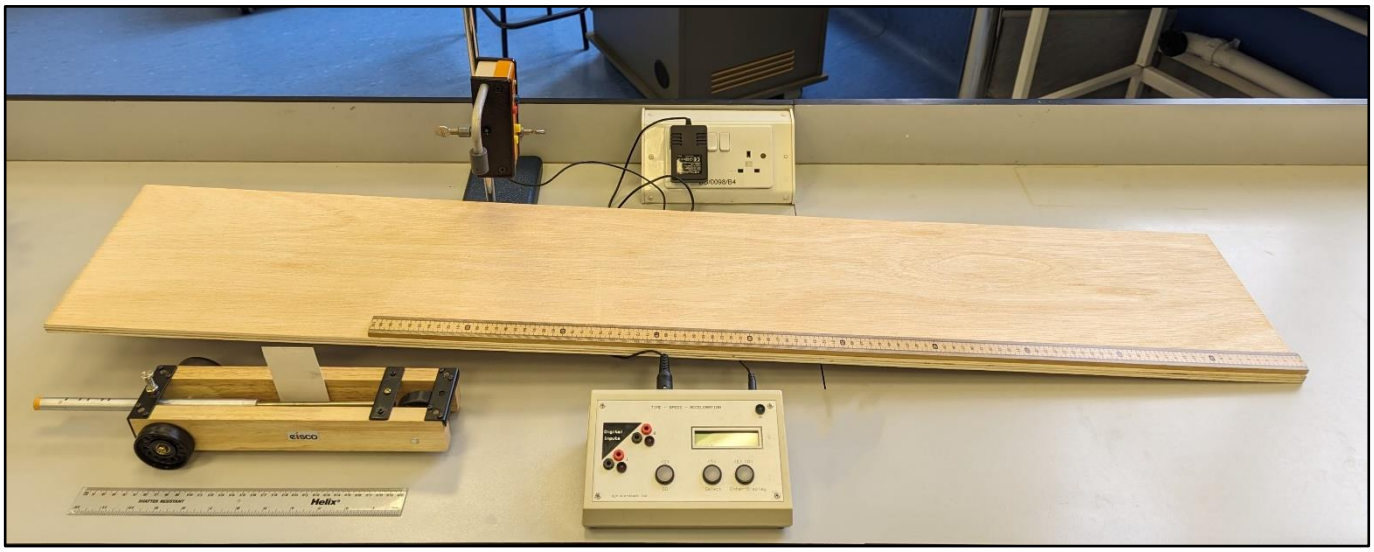
Item	Quantity
Sheet of wood for slope	1
Hotwheels track	1
Hotwheels car	1
Metre stick	1
Ruler	1
BeeSpiV	1

Procedure

1. Set up track as shown
2. Place BeeSpi V across track as shown at 0.9m from bottom of track
3. Press start to turn on the BeeSpiV
4. Ensure BeeSpi V has m/s in bottom right
    a. If 'sec' is displayed press and hold the start button.
    b. If km/h or cm/s are displayed press and hold the select button
5. Place the car at 1.0m from bottom of the slope
6. Press 'start'
7. The reading on the BeeSpiV is the speed through the BeeSpiV
8. Repeat 5-7 as required
9. Repeat 5-8 for differing release heights/positions of BeeSpiV/height of ramp as required.

Instantaneous speed

Using time in gate (Basic track and Eisco cart and TSA with 1 light gate)



Equipment list

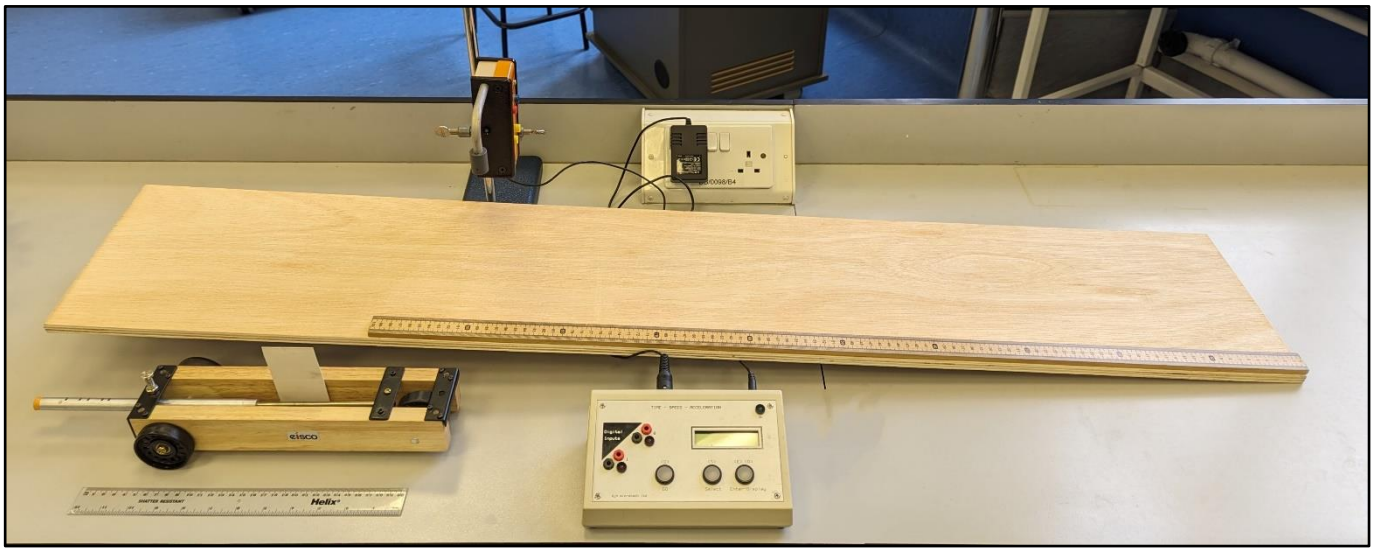
Item	Quantity
Sheet of wood for slope	1
TSA	1
Eisco cart	1
0.05m mask	1
Metre stick	1
Ruler	1
Light gate	1
Clamp stand with boss head	1

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Connect light gate to port 0
5. Switch on light gate and check alignment between source and receiver
6. Press select until TSA display shows “time interval”, press enter
7. Press enter to accept 1 light gate
8. Place cart at 1.0m from bottom of slope, ensuring it will travel straight down the slope between the gate
9. Press go
10. Release cart
11. Read time the mask takes to pass through the gate
12. Calculate speed using 0.05m/time on TSA
13. Repeat 8-13 as required
14. Repeat 8-14 for different release heights/position of gate/slope heights

Instantaneous speed

Precalculated (Basic track and Eisco cart and TSA with 1 light gate)



Equipment list

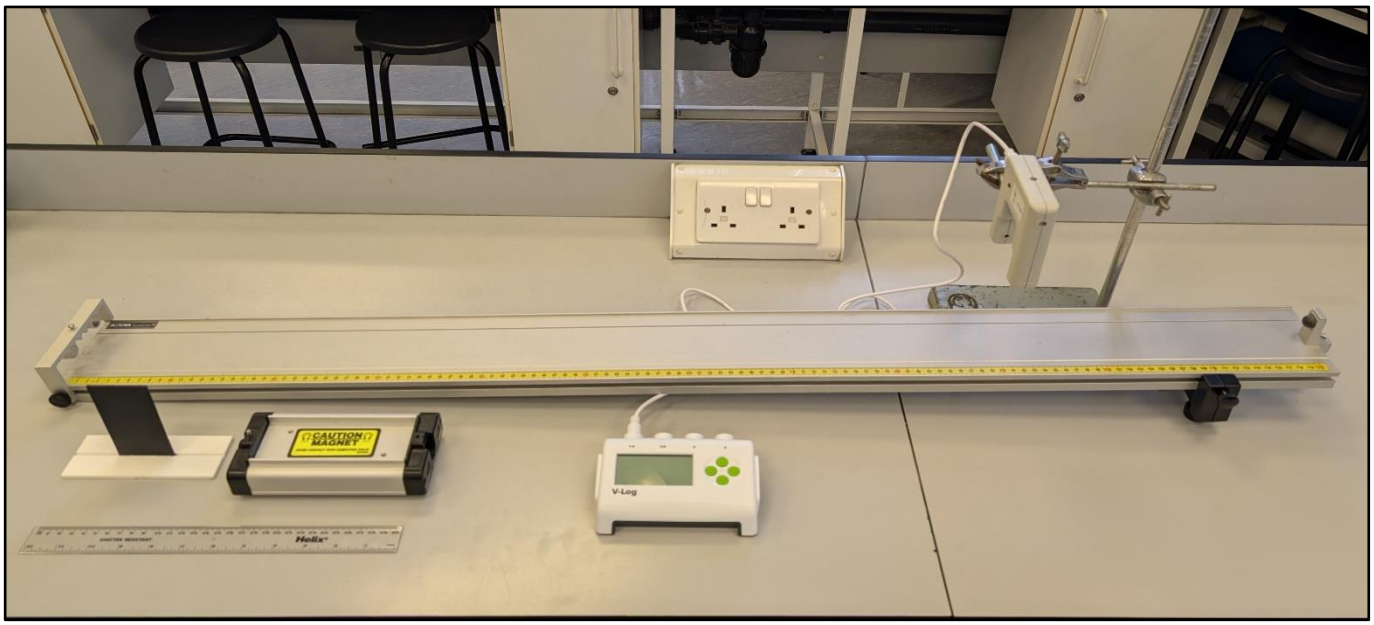
Item	Quantity
Sheet of wood for slope	1
TSA	1
Eisco cart	1
0.05m mask	1
Metre stick	1
Ruler	1
Light gate	1
Clamp stand with boss head	1

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Connect light gate to port 0
5. Switch on light gate and check alignment between source and receiver
6. Press select until TSA display shows “speed”, press enter
7. Press enter to accept for 1 light gate
8. Press select until display shows “5” for 0.05m mask, press enter
9. Place cart at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
10. Press go
11. Release cart
12. Read speed from TSA
13. Repeat 9-12 as required
14. Repeat 9-13 for different release heights/positions of gate/slope heights

Instantaneous speed

Using time in gate (PASCO track with PASCO cart, 1 Data Harvest light gate and Data Harvest V-Log4 data logger)



Equipment list

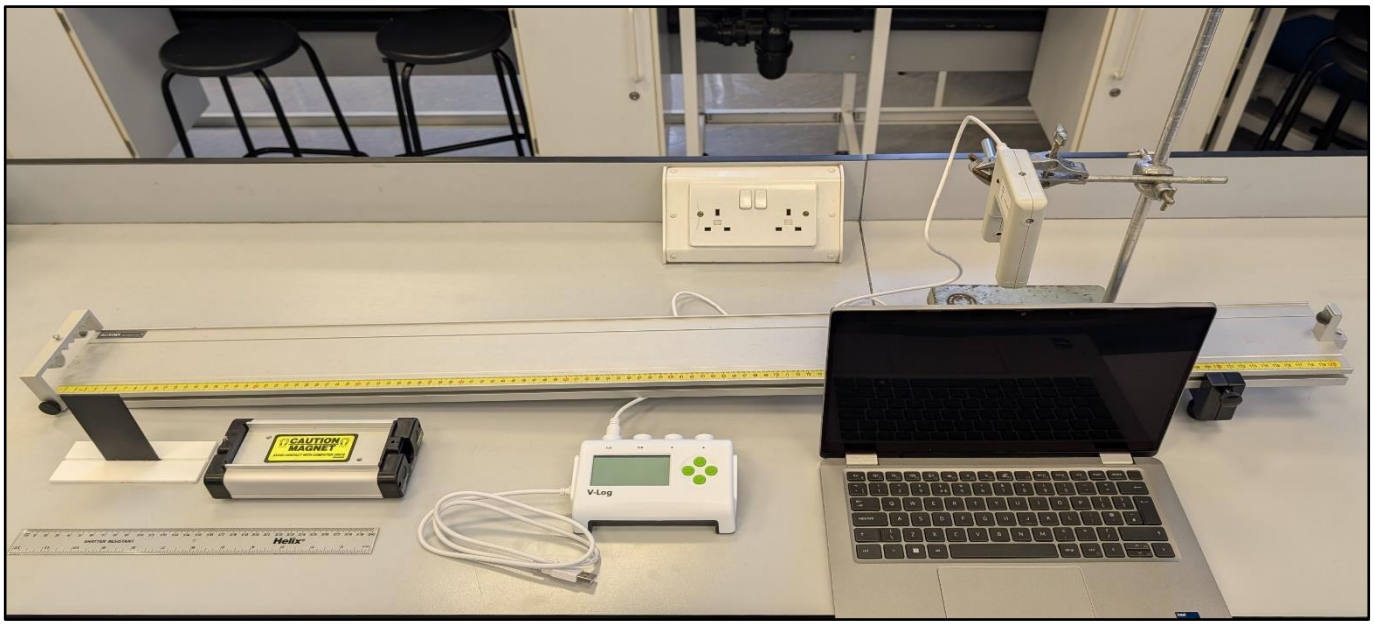
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gate	1
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place light gate at 0.9m from bottom of track
3. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Time”
    c. Select “Time at A”
4. Place cart at 1.0m from bottom of slope
5. Release cart ensuring the mask breaks the light gate beam
6. The data logger screen now indicates the time taken to pass through the light gate (take the top number)
7. Calculate speed using 0.05m/time on data logger
8. Repeat 4-7 as required (each new reading will replace the previous one)
9. After 3 runs, the bottom number gives the average time taken to pass the light gate
10. Return to the home screen by pressing the green stop button, then the right button
11. Repeat 3-10 with altered variables as required

Instantaneous speed

Using time in gate (PASCO track with PASCO cart, 1 Data Harvest light gate, Data Harvest V-Log4 data logger and laptop/phone)



Equipment list

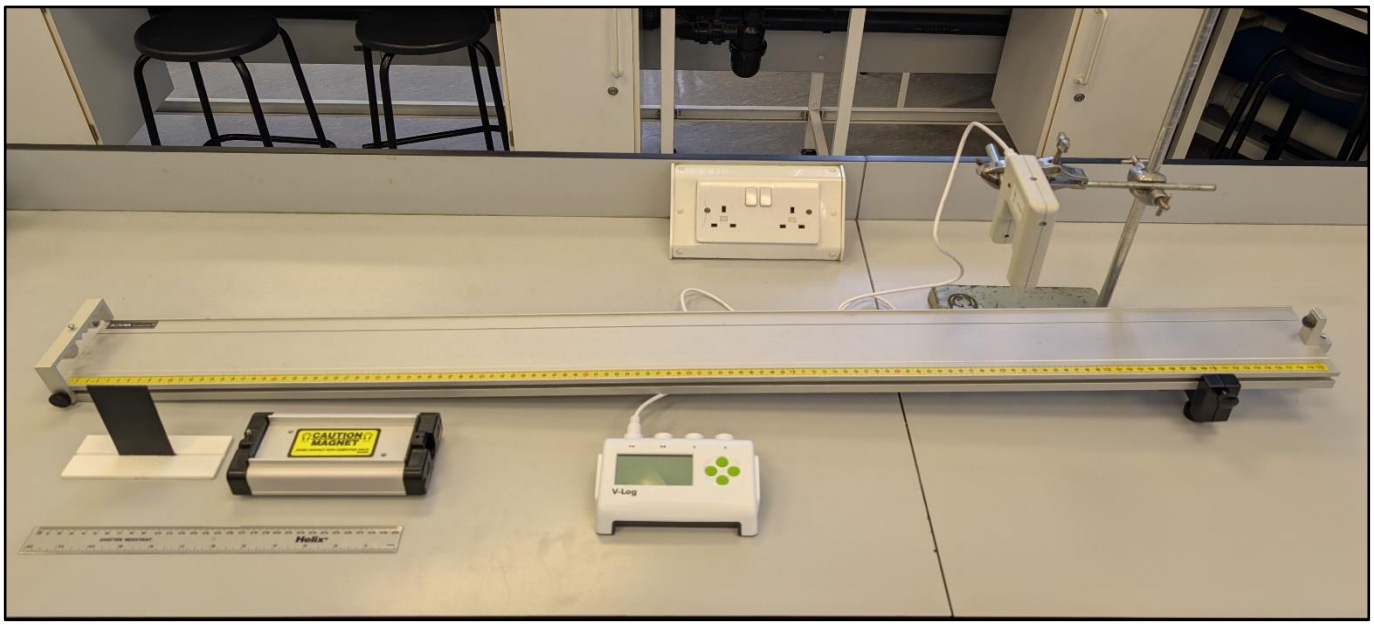
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gate	1
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

1. Set up equipment as shown
2. Place light gate at 0.9m from bottom of track
3. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
4. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Set “Timing Mode” to “Time”
    g. Ensure “Where?” is set to “At A”
    h. Close window
    i. Click “Start” (under graph)
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks the light gate beam
7. The laptop/phone screen now indicates the time taken to pass through the light gate
8. Calculate speed using 0.05m/time on screen
9. Repeat 5-8 as required (each new reading will be recorded in sequence)
10. Repeat 5-9 with altered variables as required

Instantaneous speed

Precalculated (PASCO track with PASCO cart, 1 Data Harvest light gate and Data Harvest V-Log4 data logger)



Equipment list

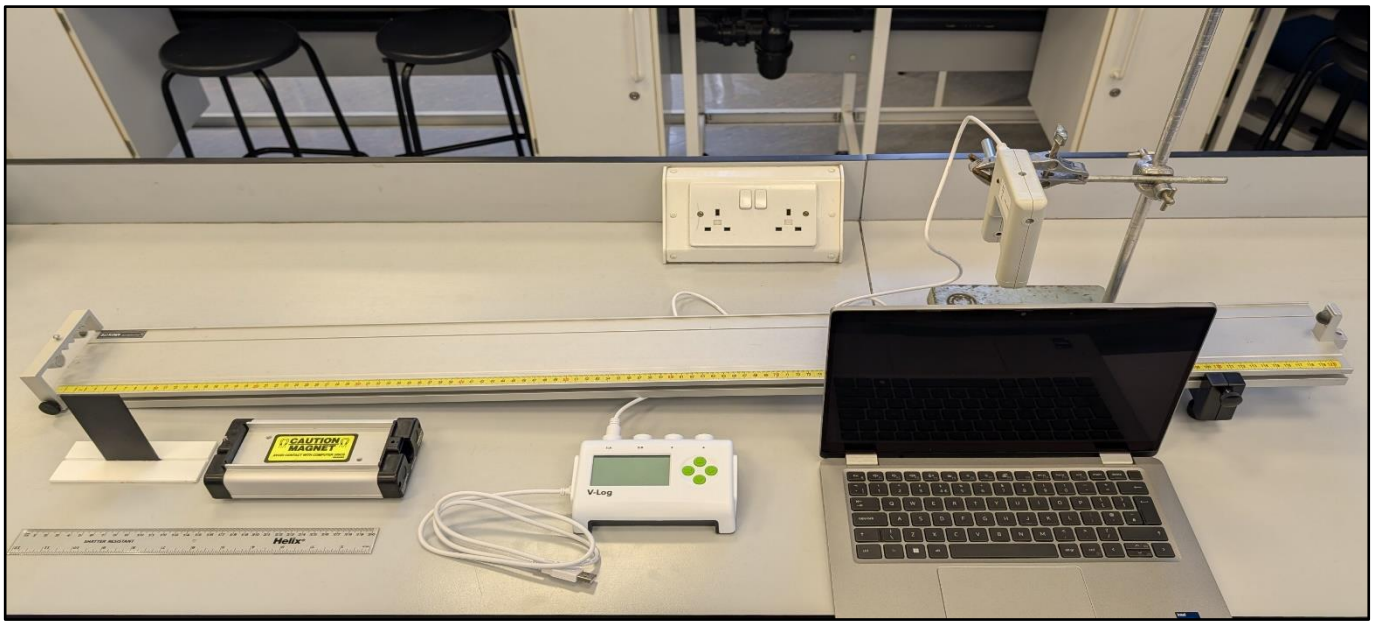
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gate	1
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place light gate at 0.9m from bottom of track
3. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Speed”
    c. Select “Speed at A”
    d. Select “Interrupt card” then change to 50mm
4. Place cart at 1.0m from bottom of slope
5. Release cart ensuring the mask breaks the light gate beam
6. The data logger screen now indicates the speed of the cart at the light gate (take the top number)
7. Repeat 4-6 as required (each new reading will replace the previous one)
8. After 3 runs, the bottom number gives the average instantaneous speed at the light gate
9. Return to the home screen by pressing the green stop button, then the right button
10. Repeat 3-9 with altered variables as required

Instantaneous speed

Precalculated (PASCO track with PASCO cart, 1 Data Harvest light gate, Data Harvest V-Log4 data logger and laptop/phone)



Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gate	1
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

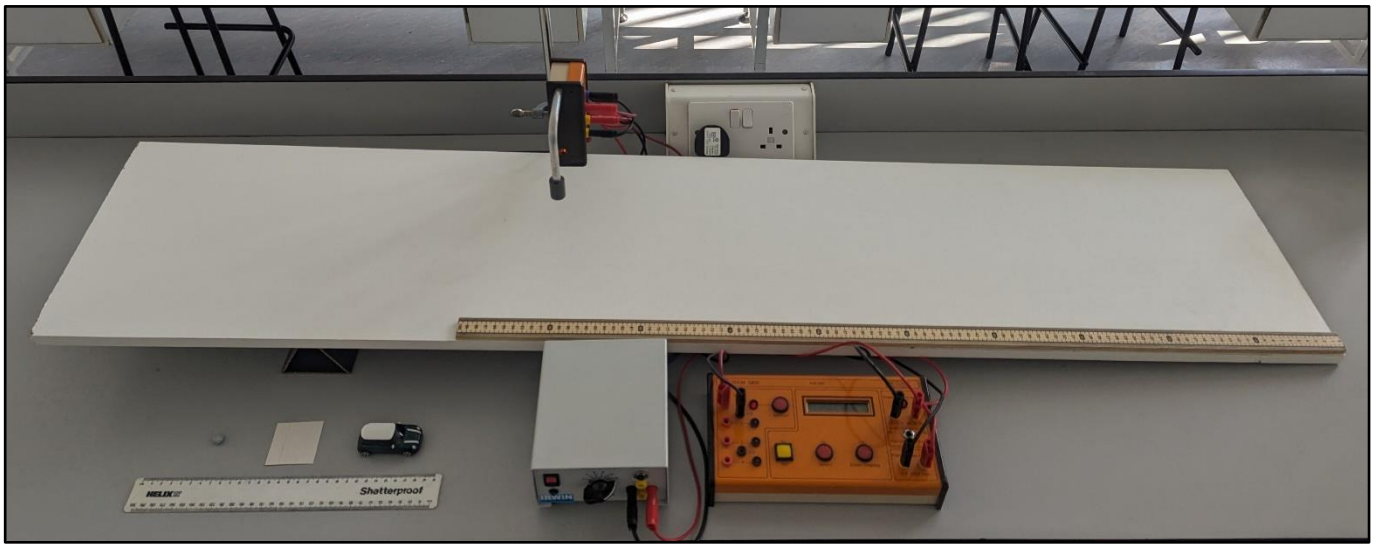
1. Set up equipment as shown
2. Place light gate at 0.9m from bottom of track
3. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
4. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Set “Timing Mode” to “Speed/velocity”
    g. Change “Apparatus” to “Single interrupt”
    h. Change “Length” (of interrupt card) to 50mm, then save
    i. Close window
    j. Click “Start” (under graph)
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks the light gate beam
7. The laptop/phone screen now indicates the speed at the light gate
8. Repeat 5-7 as required (each new reading will be recorded in sequence)
9. Repeat 5-8 with altered variables as required

Dynamics

Acceleration

Acceleration

Precalculated (Basic slope with car and QED with 1 light gate)



Equipment list

Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Car with 0.05m mask (attach to top)	1
Metre stick	1
Ruler	1
Light gate	1
Long leads	6
Clamp stand with boss head	1

Procedure

1. Set up equipment as shown ensuring wires are out of the way
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Connect light gate to port 1
5. Press select until display shows “acceleration”, press enter
6. Press select
7. Press enter to accept 1 reading
8. Press select until mask size reads 2, press enter
9. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gate
10. Press go
11. Release car
12. Press display and read acceleration on QED
13. Repeat 9-12 as required
14. Repeat 9-13 for different release heights/position of gate/slope heights

Precalculated (PASCO track with PASCO cart and 2 PASCO wireless smart gates)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO wireless smart gates	2
Laptop or phone with SPARKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first smart gate at 0.9m from bottom of track
3. Place second smart gate at 0.2m from bottom of track
4. Switch on smart gates
5. Open sparkvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click “1.23” in centre of screen
    d. Select Bluetooth symbol in top right of laptop screen
    e. Both smart gates should appear, click on gate which has the same 6 digit code as the gate at 0.2m
    f. Click cancel
    g. Click on gate which has the same 6 digit code as the gate at 0.9m
    h. Select “smart gate and auxiliary port”
    i. Select “photogate timing (2 photogates)”
    j. Click ok
    k. Ensure flag length matches mask (in this case 0.05m)
    l. Ensure photogate spacing matches distance between gates (in this case 0.7m)
    m. Select “ok”
    n. Select “done”
    o. Top right of screen, click “select measurement”
    p. Select “acceleration between gates”
6. Place cart at 1.0m from bottom of slope
7. Click “start”
8. Release cart ensuring the mask breaks both light gate beams
9. Press stop once cart reaches bottom of slope
10. The screen now indicates the acceleration of the cart between gates.
11. Repeat 6-10 as required
12. Repeat 6-11 with altered variables as required
13. Switch off smart gates

Using velocity in gates (PASCO track with PASCO cart and 2 PASCO wireless smart gates)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
PASCO wireless smart gates	2
Laptop or phone with SPARKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first smart gate at 0.9m from bottom of track
3. Place second smart gate at 0.2m from bottom of track
4. Switch on smart gates
5. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose 8th option (3 grey rectangles)
    c. Click “1.23” in each rectangle
    d. Select Bluetooth symbol in top right of laptop screen
    e. Both smart gates should appear, click on gate which has the same 6 digit code as the gate at 0.2m
    f. Click cancel
    g. Click on gate which has the same 6 digit code as the gate at 0.9m
    h. Select “smart gate and auxiliary port”
    i. Select “photogate timing (2 photogates)”
    j. Click ok
    k. Ensure flaglength matches mask (in this case 0.05m)
    l. Ensure photogate spacing matches distance between gates (in this case 0.7m)
    m. Select “ok”
    n. Select “done”
    o. In first column, click “select measurement”
    p. Select “Velocity in gate, Ch 1:1_1”
    q. In second column, click “select measurement”
    r. Select “Velocity in gate, Ch 1:1_2”
    s. In third column, click “select measurement”
    t. Select “Time between gates”
6. Place cart at 1.0m from bottom of slope
7. Click “start”
8. Release cart ensuring the mask breaks both light gate beams
9. Press stop once cart reaches bottom of slope
10. Calculate the change in speed by v(second column)-u(first column)
11. Divide the value from step 30 by t(third column), to find acceleration
12. Repeat 6-11 as required
13. Repeat 6-12 with altered variables as required
14. Switch off smart gates

Acceleration

Precalculated (PASCO track with PASCO wireless cart)

NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Equipment list

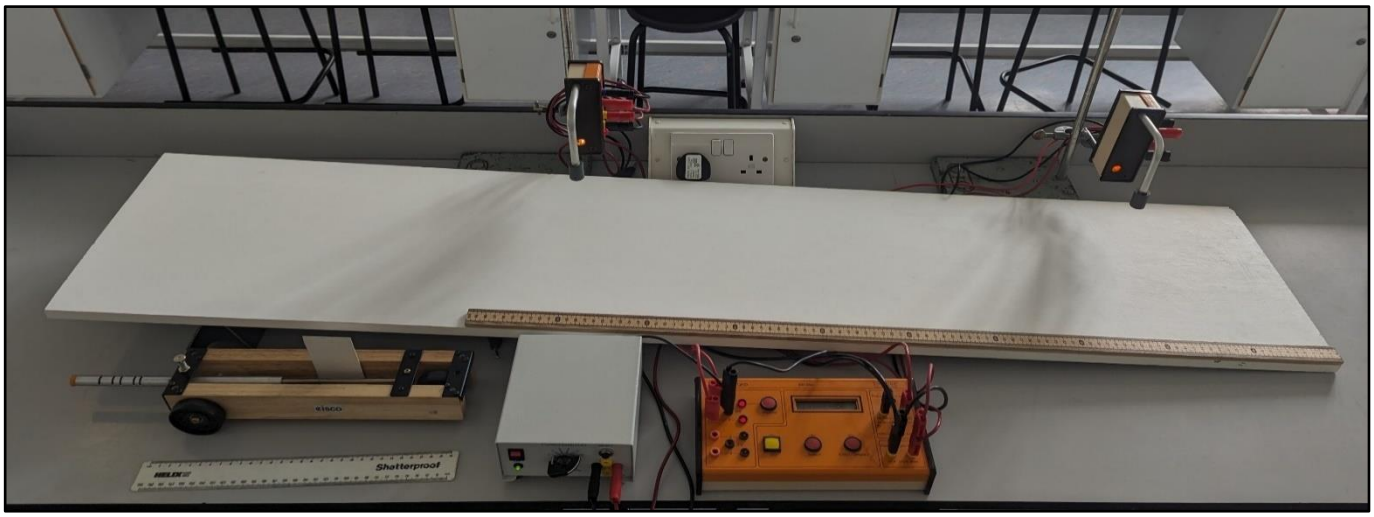
Item	Quantity
1.2m PASCO track	1
PASCO cart (wireless)	1
Laptop or phone with SPAKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Turn on wireless cart
3. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click line graph (top left option) in centre of screen
    d. Select Bluetooth symbol in top right of laptop screen
    e. Choose wireless smartcart which has the same 6 digit code as the cart
    f. Select “done”
    g. In bottom left corner of the screen, click “mixed”
    h. Increase sample rate to 200Hz
    i. Click “stop condition”
    j. For condition type select “time based”
    k. For record time enter “1”
    l. Click ok
    m. At top left of graph select measurement
    n. Select “acceleration”
4. Place cart at 1.0m from bottom of slope
5. Click “start” and release cart simultaneously
6. Select line of best fit icon at bottom of screen
7. The value “b” is the acceleration
8. Repeat 4-7 as required
9. Repeat 4-8 with altered variables as required
10. Switch off wireless cart

Acceleration

Precalculated - (Basic slope with simple cart and QED with 2 light gates)



Equipment list

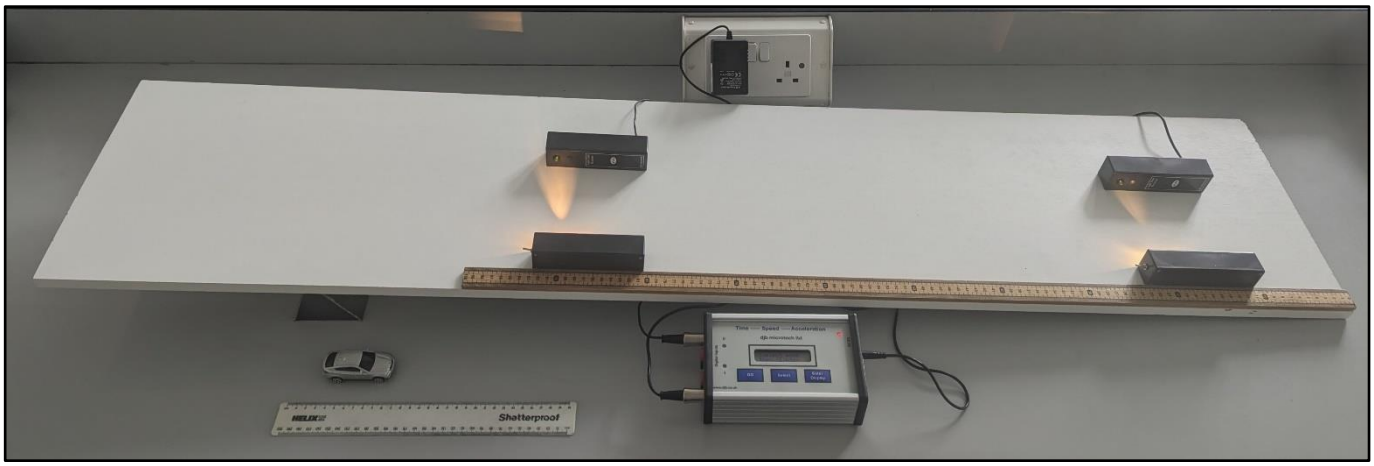
Item	Quantity
Sheet of wood for slope	1
QED	1
Power pack (12V)	1
Cart with 0.05m mask	1
Metre stick	1
Ruler	1
Light gates	2
Long leads	10
Clamp stands with boss head	2

Procedure

1. Setup equipment as shown ensuring wires are out of the way
2. Lay meter stick on slope
3. Place light gates on clamp stands at 0.2m and 0.9m from bottom of slope
4. Connect 0.9m light gate to port 1
5. Connect 0.2m light gate to port 2
6. Press select until display shows “acceleration”, press enter
7. Press select
8. Press enter to accept 1 readings
9. Press select until mask size reads 5, press enter
10. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
11. Press go
12. Release car
13. Press display and read acceleration on QED
14. Repeat 10-13 as required
15. Repeat 10-14 for different release heights/position of gates/slope heights

Acceleration

Precalculated - (Basic slope with car and TSA with 2 light gates positioned horizontally)



Equipment list

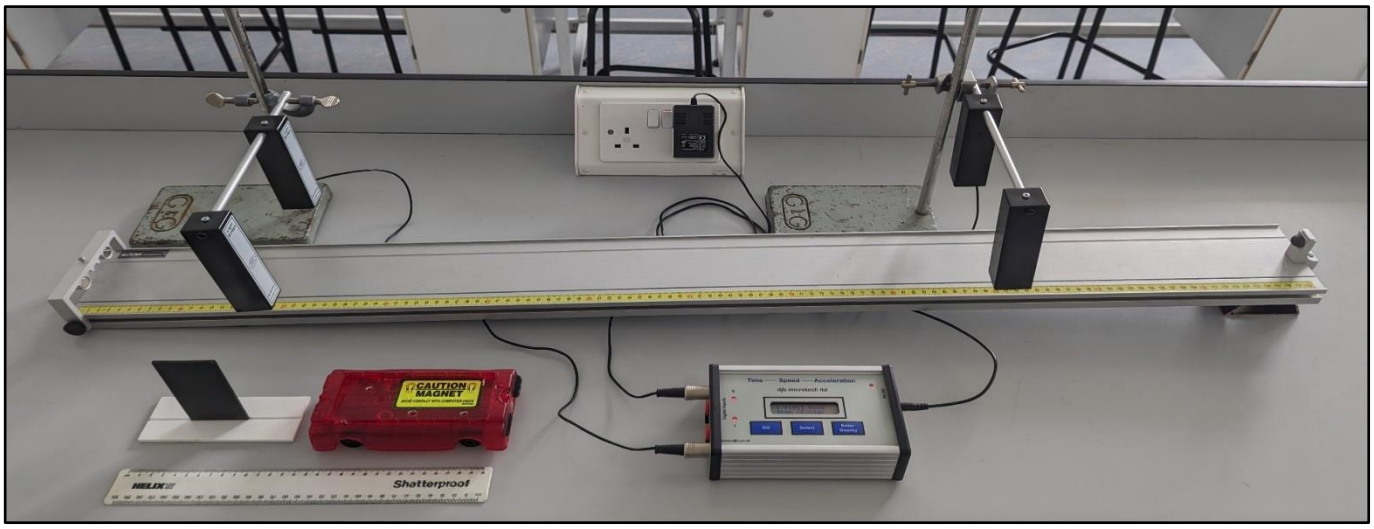
Item	Quantity
Sheet of wood for slope	1
TSA	1
Car with 0.05m mask	1
Metre stick	1
Ruler	1
Light gates (light source and receiver)	2

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Place light gates at 0.2m and 0.9m from bottom of slope
4. Connect 0.9m light gate to port 0
5. Connect 0.2m light gate to port 1
6. Switch on light gates and check alignment between source and receiver (green light will show on receiver)
7. Press select until display shows “acceleration”, press enter
8. Press enter to accept 1 reading
9. Press select until mask size reads 5, press enter
10. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
11. Press go
12. Release car
13. Press display and read acceleration on QED
14. Repeat 10-13 as required
15. Repeat 10-14 for different release heights/position of gates/slope heights

Acceleration

Precalculated (PASCO track with PASCO cart and TSA with 2 light bridges)



NB This can be completed with light gates but you may require 2 further clamp stands.

Equipment list

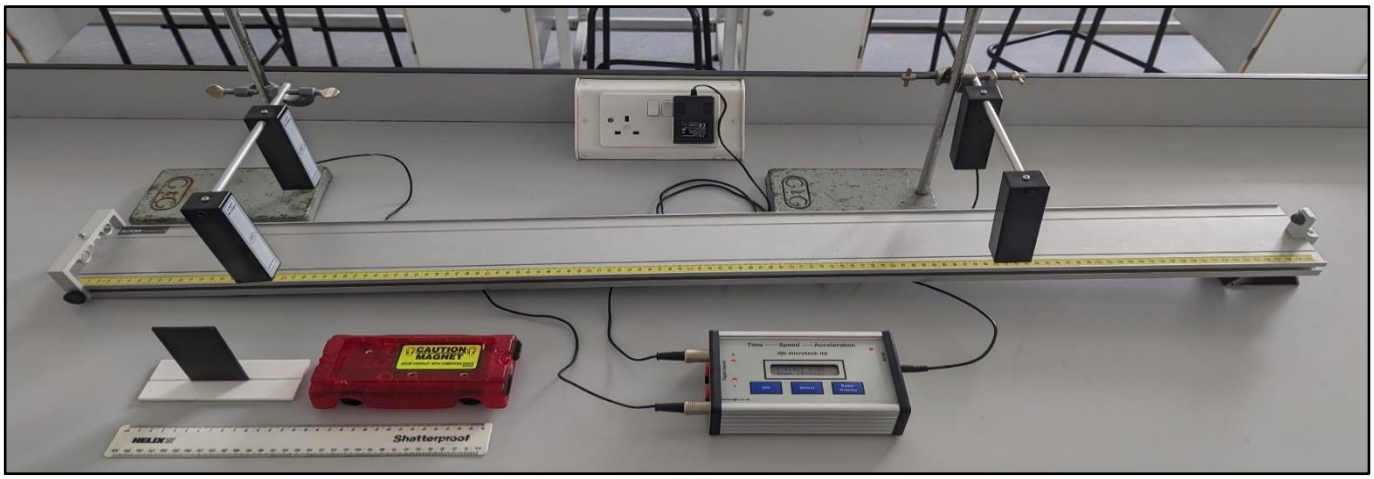
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
TSA	1
Light bridges	2
Clamp stands with boss head	2
Ruler	1

Procedure

1. Set up equipment as shown
2. Place light bridges on clamp stands at 0.2m and 0.9m from bottom of slope
3. Connect 0.9m light bridge to port 0
4. Connect 0.2m light bridge to port 1
5. Press select until display shows “acceleration”
6. Press enter to accept 1 reading
7. Press select until display show 5cm, press enter
8. Place cart at 1.0m from bottom of slope, ensuring it will cut the light bridge beams
9. Press go
10. Release cart
11. Read acceleration on TSA
12. Repeat 8-11 as required
13. Repeat 8-12 for different release heights/distances between gates/slope heights

Acceleration

Using acceleration data to calculate (PASCO track with PASCO cart and TSA with 2 light bridges)



NB This can be completed with light gates but you may require 2 further clamp stands.

Equipment list

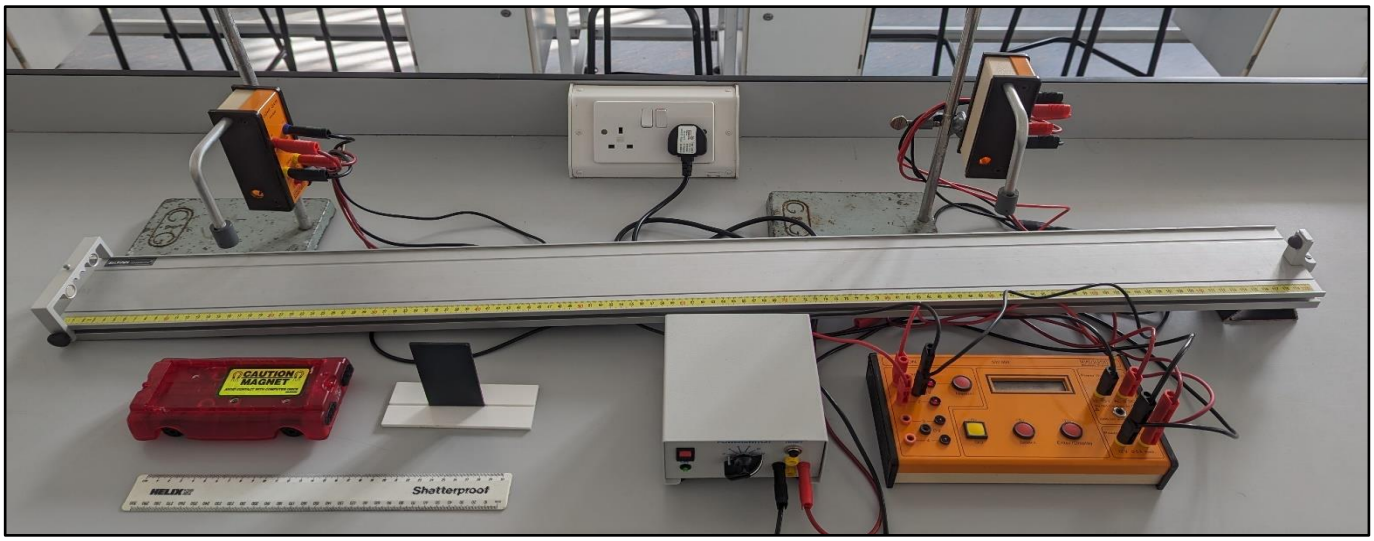
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
TSA	1
Light bridges	2
Clamp stands with boss head	2
Ruler	1

Procedure

1. Set up equipment as shown
2. Place light bridges on clamp stands at 0.2m and 0.9m from bottom of slope
3. Connect 0.9m light bridge to port 0
4. Connect 0.2m light bridge to port 1
5. Press select until display shows “acc. data”
6. Press enter
7. Press select until display show 5cm, press enter
8. Place cart at 1.0m from bottom of slope, ensuring it will cut the light bridge beams
9. Press go
10. Release cart
11. Display shows v2 and v1 on TSA
12. Calculate v2-v1 using TSA displayed values
13. Press display
14. Divided the value from step 12 by the time on the TSA to calculate acceleration
15. Repeat 8-14 as required
16. Repeat 8-15 for different release heights/distances between gates/slope heights

Acceleration

Precalculated (PASCO track and PASCO cart and QED with 2 light gates)



Equipment list

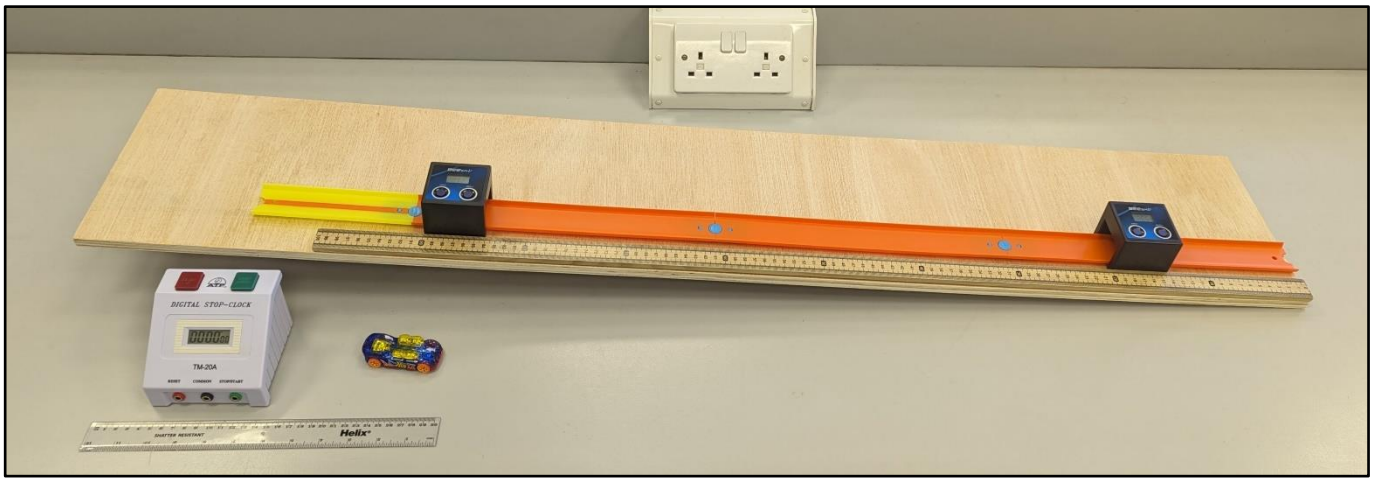
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
QED	1
Power pack (12V)	1
Long leads	10
Light gates	2
Clamp stands with boss head	2
Ruler	1

Procedure

1. Set up track as shown
2. Place light gates on clamp stands at 0.2m and 0.9m from bottom of slope
3. Connect 0.9m light gate to port 1
4. Connect 0.2m light gate to port 2
5. Press select until display shows “acceleration”, press enter
6. Press select
7. Press enter to accept 1 readings
8. Press select until mask size reads 5, press enter
9. Place car at 1.0m from bottom of slope, ensuring it will travel straight down the slope between gates
10. Press go
11. Release car
12. Press display and read acceleration on QED
13. Repeat 9-12 as required
14. Repeat 9-13 for different release heights/position of gates/slope heights

Acceleration

Using manual timing (Basic slope with hot wheels track and 2 BeeSpiVs)



Equipment list

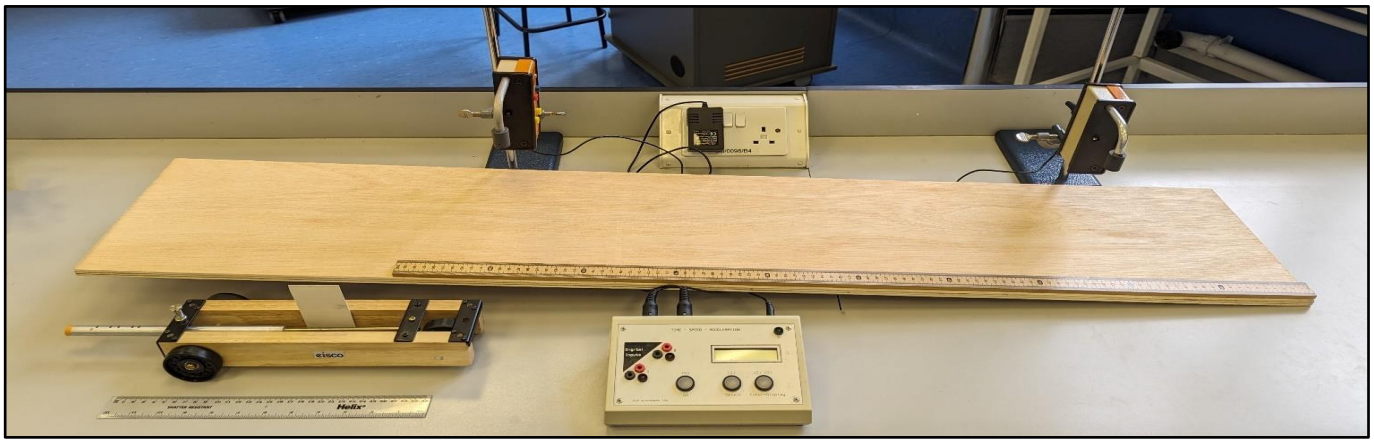
Item	Quantity
Sheet of wood for slope	1
Hotwheels track	1
Hotwheels car	1
Metre stick	1
Ruler	1
Timer	1
BeeSpiV	2

Procedure

1. Set up track as shown
2. Place BeeSpiVs across track as shown at 0.9m and 0.2m from bottom of track
3. Press start to turn on the BeeSpiVs
4. Ensure BeeSpiVs have m/s in bottom right
    a. If 'sec' is displayed press and hold the start button
    b. If km/h or cm/s are displayed press and hold the select button
5. Press 'start' on both BeeSpiVs
6. Place the car at 1.0m from bottom of the slope
7. Be prepared to start the timer when it exits the first BeeSpiV and stop it when it exits the second
8. Release the car and start the timer when it exits the first BeeSpiV and stop it when it exits the second
9. The readings on the BeeSpiV are the speeds in each BeeSpiV
10. Subtract the second BeeSpiV reading from the first, then divide by the time on the timer
11. This calculation gives the acceleration
12. Repeat 6-11 as required
13. Repeat 6-12 for differing release heights/positions of BeeSpiV/height of ramp as required

Acceleration

Precalculated (Basic slope and Eisco cart and TSA with 2 light gates)



Equipment list

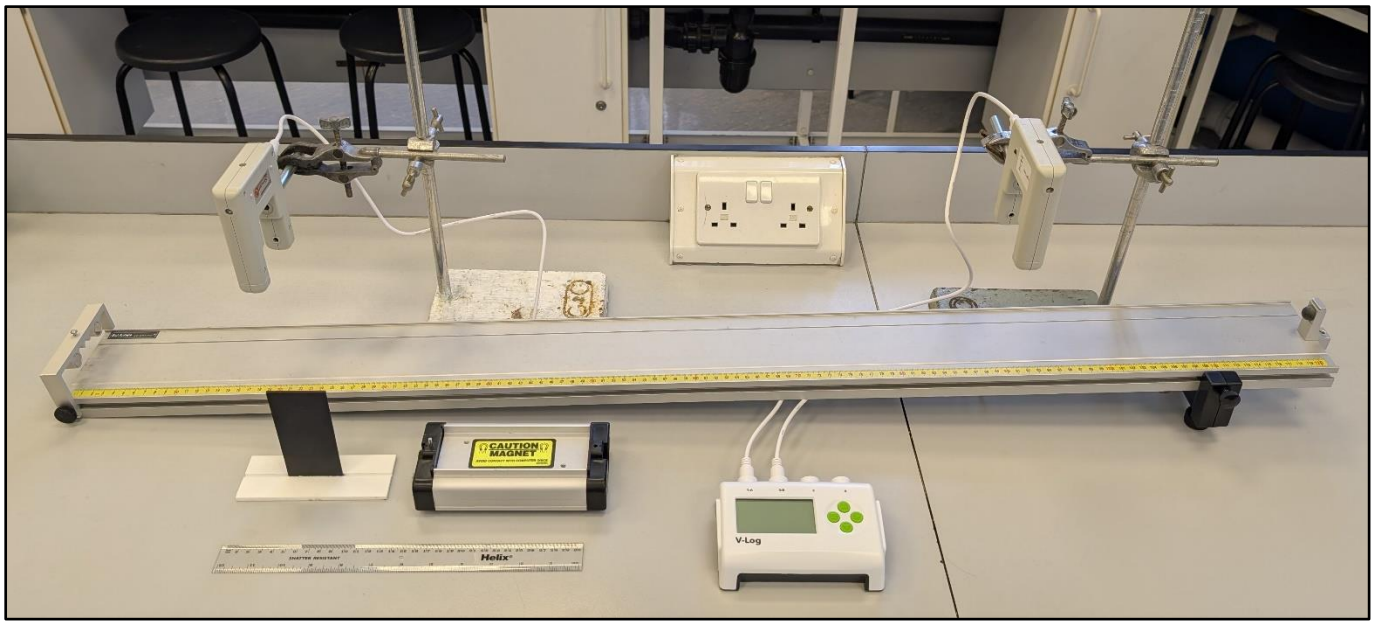
Item	Quantity
Sheet of wood for slope	1
TSA	1
Eisco cart	1
0.05m mask	1
Metre stick	1
Ruler	1
Light gate	2
Clamp stands with boss head	2

Procedure

1. Set up equipment as shown
2. Lay meter stick on slope
3. Place light gate at 0.9m from bottom of slope
4. Place light gate at 0.9m from bottom of slope
5. Connect light gate at 0.9m to port 0
6. Connect light gate at 0.2m to port 1
7. Switch on light gates and check alignment between source and receiver
8. Press select until TSA display shows “acceleration”, press enter
9. Press enter to accept 1 reading
10. Press select until reading says “5” for 0.05m mask length, press enter
11. Place cart at 1.0m from bottom of slope, ensuring it will travel straight down the slope between the gates
12. Press go
13. Release cart
14. Read acceleration from TSA
15. Repeat 11-14 as required
16. Repeat 11-15 for different release heights/position of gate/slope height

Acceleration

Precalculated (PASCO track with PASCO, 2 Data Harvest light gates and Data Harvest V-Log4 data logger)



Equipment list

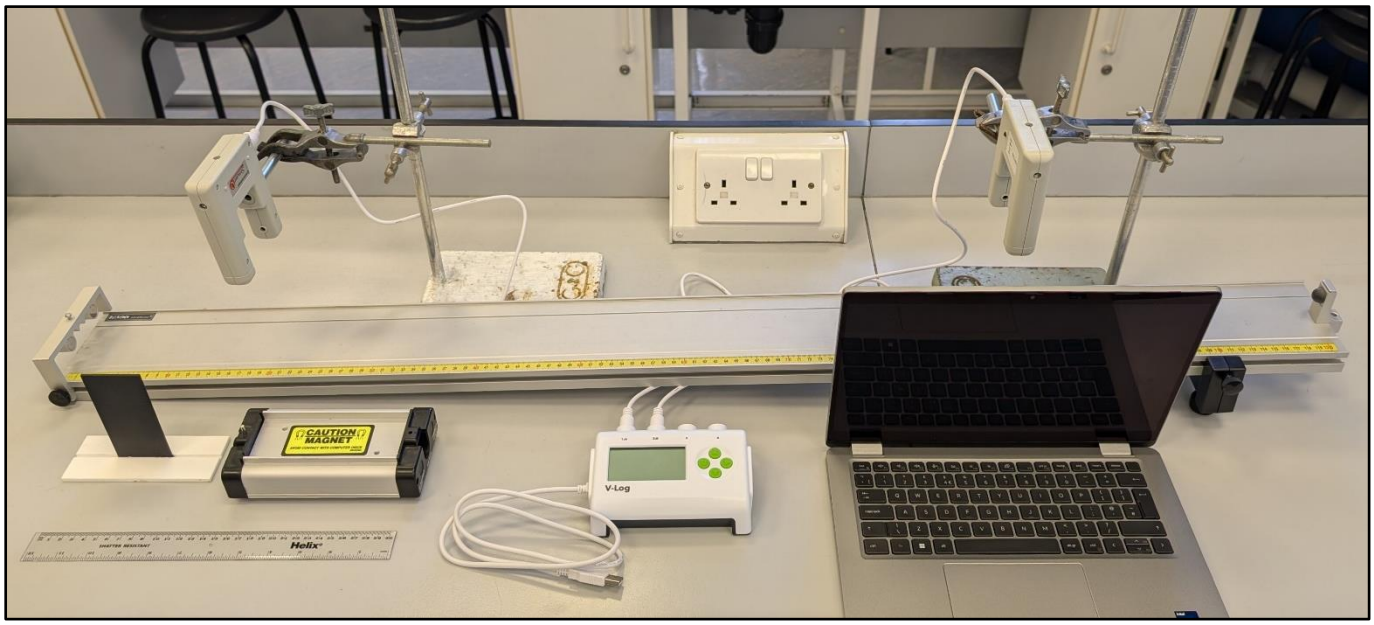
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Acceleration”
    c. Select “Acceleration A to B”
    d. Select “Interrupt card”, then change to 50mm
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks both light gate beams
7. The data logger screen now indicates the acceleration of the cart between gates (take the top number)
8. Repeat 5-7 as required (each new reading will replace the previous one)
9. After 3 runs, the bottom number gives the average acceleration between gates
10. Return to the home screen by pressing the green stop button, then the right button
11. Repeat 4-10 with altered variables as required

Acceleration

Precalculated (PASCO track with PASCO cart, 2 Data Harvest light gates, Data Harvest V-Log4 data logger and laptop/phone)



Equipment list

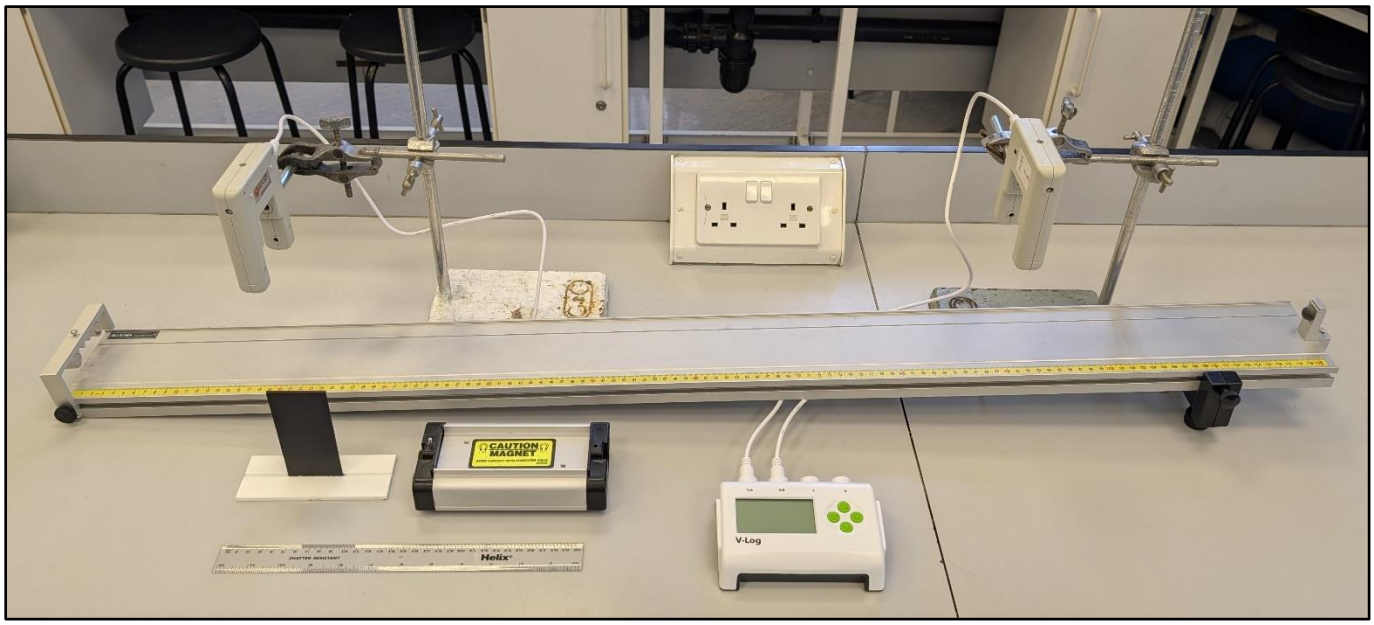
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
5. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Change “Timing Mode” to “Acceleration”
    g. Change “Where?” to “From A to B”
    h. Change “Length” (of interrupt card) to 50mm, then save
    i. Close window
    j. Click “Start” (under graph)
6. Place cart at 1.0m from bottom of slope
7. Release cart ensuring the mask breaks both light gate beams
8. The laptop/phone screen now indicates the acceleration between gates
9. Repeat 6-8 as required (each new reading will be recorded in sequence)
10. Repeat 6-9 with altered variables as required

Acceleration

Using velocity in gates (PASCO track with PASCO cart, 2 Data Harvest light gates and Data Harvest V-Log4 data logger)



Equipment list

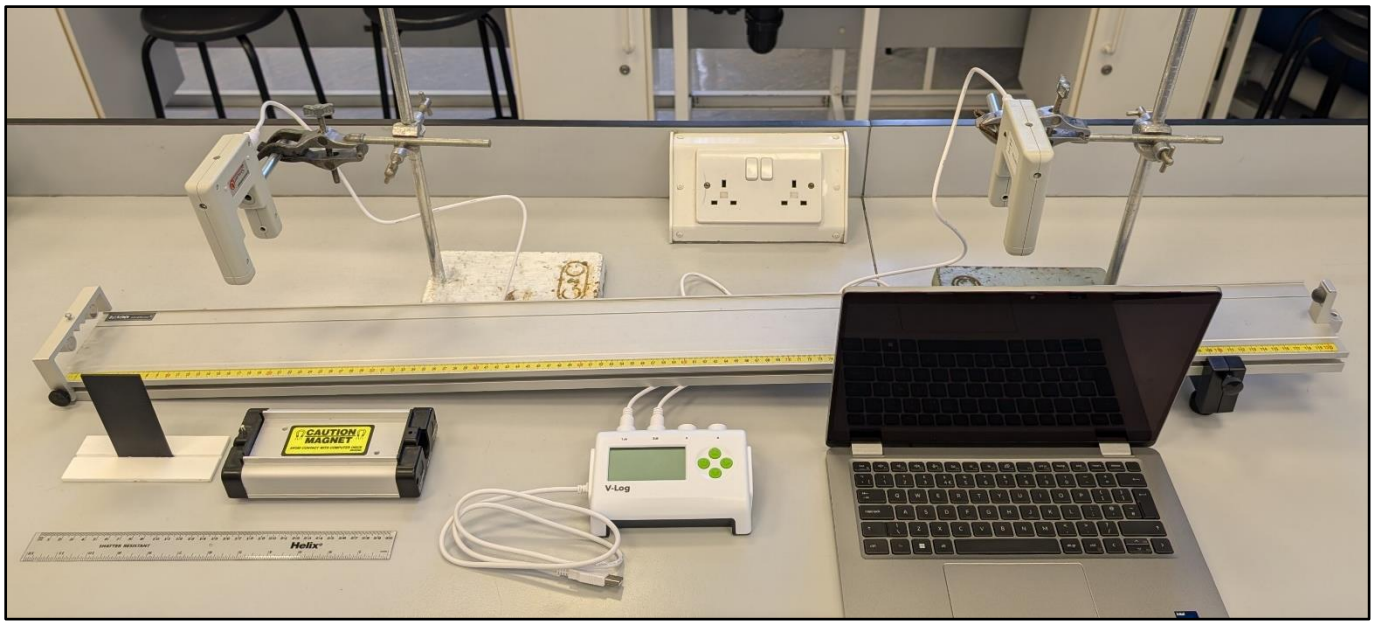
Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Press any green button on the data logger to switch it on
    a. Select “Timing” on the menu (use green down button, then right button to select)
    b. Select “Speed”
    c. Select “Speed at A then B”
    d. Select “Interrupt card”, then change to 50mm
5. Place cart at 1.0m from bottom of slope
6. Release cart ensuring the mask breaks both light gate beams
7. The data logger screen now indicates the average speed at both gates
8. Calculate the change in speed by B-A
9. Divide the value from step 8 t to find acceleration
10. Repeat 5-9 as required (each new reading will replace the previous one)
11. Repeat 4-10 with altered variables as required

Acceleration

Using velocity in gates (PASCO track with PASCO cart, 2 Data Harvest light gates, Data Harvest V-Log4 data logger and laptop/phone)



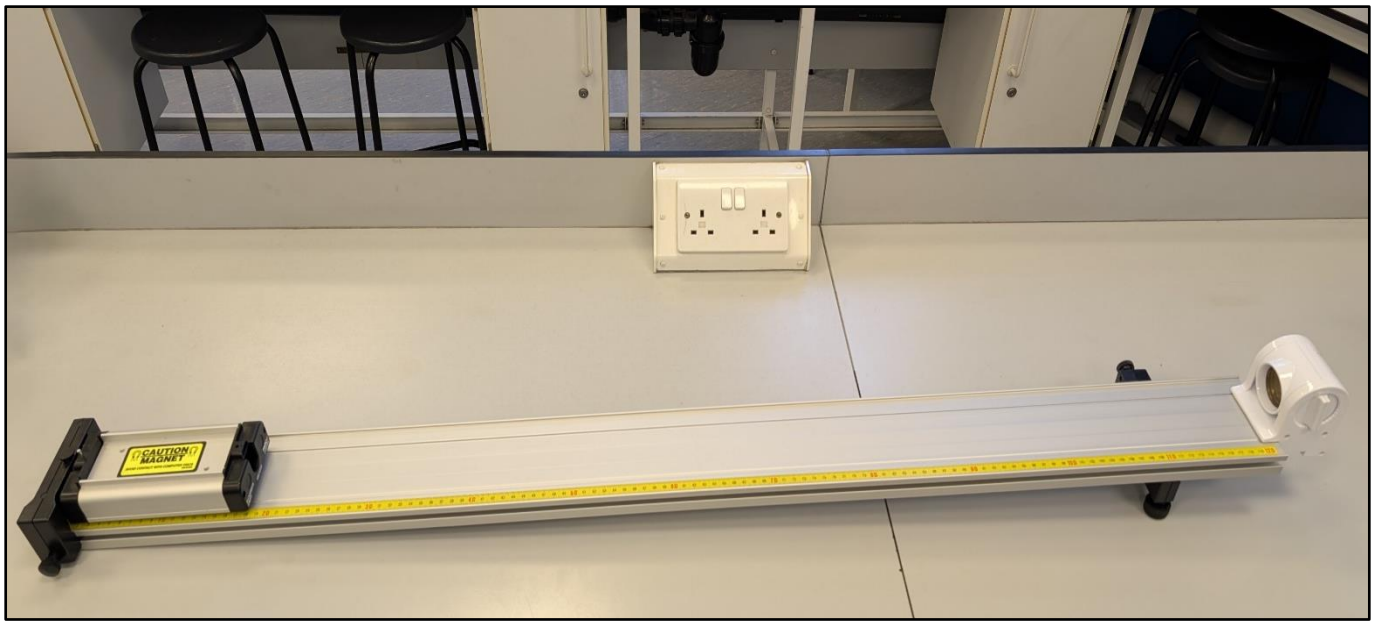
Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
0.05m mask	1
Data Harvest light gates	2
Data Harvest V-Log4 data logger	1
Ruler	1
Laptop or phone with EasySense2 installed	1

Procedure

1. Set up equipment as shown
2. Place first light gate at 0.9m from bottom of track
3. Place second light gate at 0.2m from bottom of track
4. Connect the data logger to the laptop/phone
    a. If using a wired connection, ensure the data logger is returned to the home screen
    b. If using Bluetooth, select on data logger menu (leave in this mode), then pair on device
5. Open EasySense2 on laptop/phone
    a. Select “Devices” from top left of screen
    b. Connect to data logger (if using Bluetooth, match the name displayed on screen)
    c. Ensure both light gates are displayed (refresh if not) then close the window
    d. Choose “Timing” from the experiment menu
    e. Click “Setup” at bottom left of screen
    f. Change “Timing Mode” to “Speed/Velocity”
    g. Change “Where?” to “At A then B”
    h. Change “Length” (of interrupt card) to 50mm, then save
    i. In “Series”, switch on “Time A to B”
    j. Close window
    k. Click “Start” (under graph)
6. Place cart at 1.0m from bottom of slope
7. Release cart ensuring the mask breaks both light gate beams
8. The laptop/phone screen now indicates the average speed at both gates
9. Calculate the change in speed by B-A
10. Divide the value from step 7 by Time A to B to find acceleration
11. Repeat 6-10 as required (each new reading will be recorded in sequence)
12. Repeat 6-11 with altered variables as required

Precalculated (PASCO track with PASCO cart, PASCO motion sensor and laptop/phone)



NB A phone can be used for SPARKvue instead of a laptop, and Capstone could be used instead. The measurements remain the same.

Each smart gate includes two light gates. This procedure uses only one, which is the one furthest from the on button.

Equipment list

Item	Quantity
1.2m PASCO track	1
PASCO cart (standard)	1
PASCO motion sensor	1
Laptop or phone with SPARKvue installed	1
Ruler	1

Procedure

1. Set up equipment as shown
2. Turn on motion sensor
3. Open SPARKvue on laptop
    a. Select “build new experiment”
    b. Select layout, choose first option (grey rectangle)
    c. Click line graph (top left option) in centre of screen
    d. Select Bluetooth symbol in top right of laptop screen
    e. Choose motion sensor which has the same 6 digit code as your set up
    f. Select “done”
    g. In bottom left corner of the screen, click “mixed”
    h. Increase sample rate to 200Hz
    i. Click “stop condition”
    j. For condition type select “time based”
    k. For record time enter “1”
    l. Click ok
    m. At top left of graph select measurement
    n. Select “acceleration”
4. Place cart at 1.0m from bottom of slope
5. Click “start” and release cart simultaneously
6. Select line of best fit icon at bottom of screen
7. The value “b” is the acceleration
8. Repeat 4-7 as required
9. Repeat 4-8 with altered variables as required
10. Switch off motion sensor

Waves

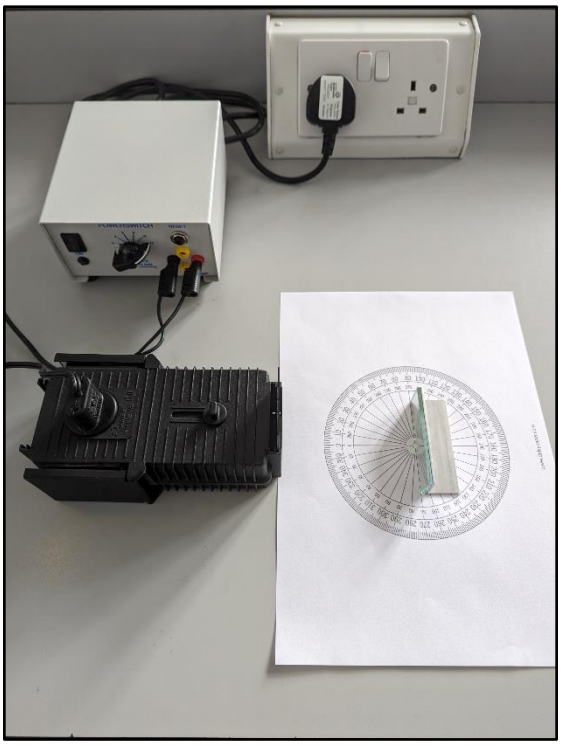
Reflection

Reflection

Ray box

Equipment list

Item	Quantity
12V power pack (set to 12V)	1
Ray box (plastic) with single slit	1
Mirror (plane)	1
Printed protractor	1



Procedure

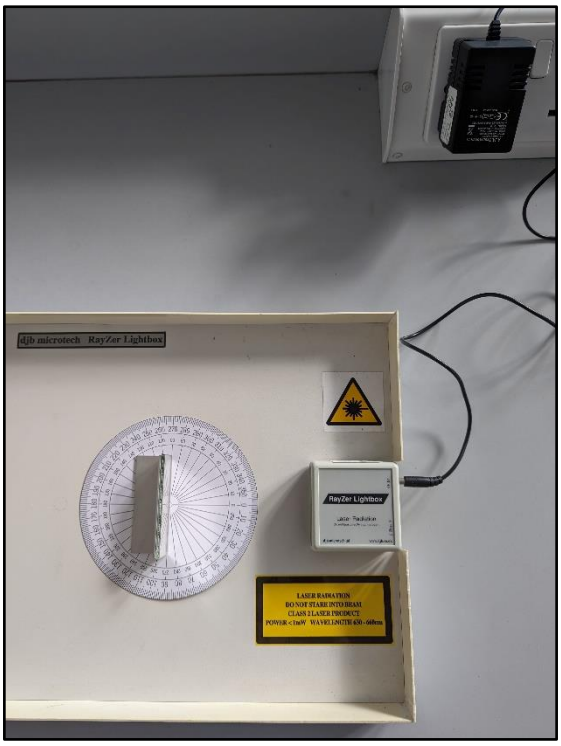
1. Set up as shown above (ray box facing zero on protractor)
2. Place mirror along the 90-270˚ line on the printed protractor (with the mirror facing zero)
3. Switch on ray box
4. Align single ray along 0˚ line to centre of mirror
5. Note the reflected ray is also at 0˚
6. Using the outer degree scale, move the ray box so the ray aligns along the 10˚ line
7. Measure the reflected ray using the smaller internal degree scale
8. Repeat every 10˚ up to 80˚

Reflection

RayZer

Equipment list

Item	Quantity
Rayzer set to single ray	1
Mirror (plane)	1
Printed protractor	1



Procedure

1. Set up as shown above (Rayzer facing zero on protractor)
2. Place mirror along the 90-270˚ line on the printed protractor (with the mirror facing zero)
3. Switch on Rayzer
4. Align single ray along 0˚ line to centre of mirror
5. Note the reflected ray is also at 0˚
6. Using the outer degree scale, move the protractor and mirror (keep in place on 90-270˚ line) so the ray aligns along the 10˚ line
7. Measure the reflected ray using the smaller internal degree scale
8. Repeat every 10˚ up to 80˚

Waves

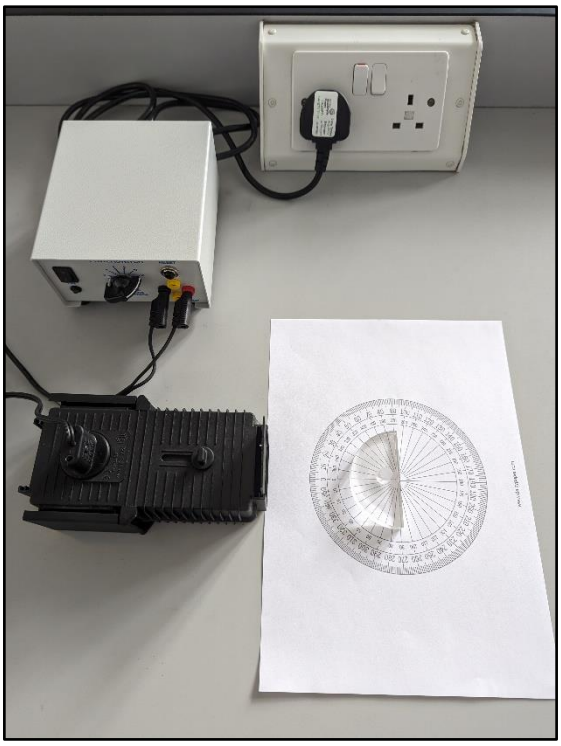
Refraction

Refraction

Ray box

Equipment list

Item	Quantity
12V power pack (set to 12V)	1
Ray box (plastic) with single slit	1
Perspex D block	1
Printed protractor	1



Procedure

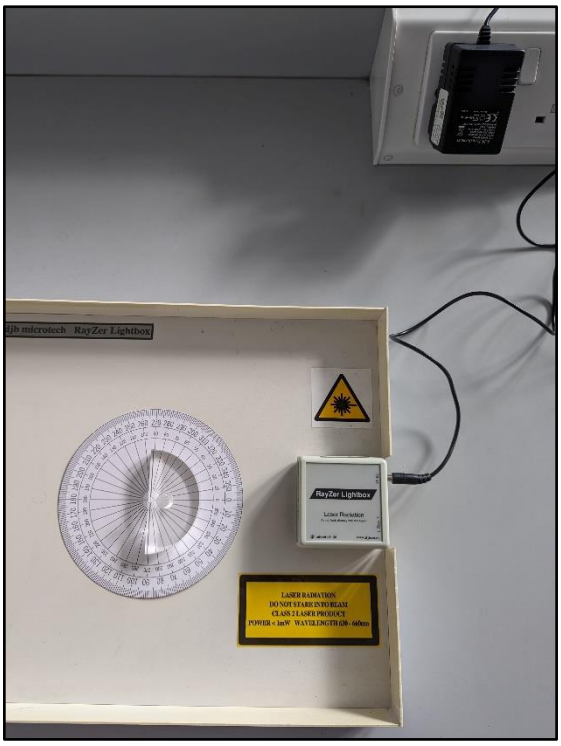
1. Set up as shown above (ray box facing zero on protractor)
2. Place D block along the 90-270˚ line on the printed protractor (with the round surface facing zero)
3. Switch on ray box
4. Align single ray along 0˚ line to centre of block
5. Note the refracted ray is along the 180˚ line, which is the normal (0˚ to the surface)
6. Using the outer degree scale, move the ray box so the ray aligns along the 5˚ line
7. Note the refracted ray using the outer degree scale
8. Calculate the angle of refraction by subtracting 180 from this value
9. Repeat every 5˚ up to 40˚

Refraction

RayZer

Equipment list

Item	Quantity
Rayzer set to single ray	1
Perspex D block	1
Printed protractor	1



Procedure

1. Set up as shown above (Rayzer facing zero on protractor)
2. Place D block along the 90-270˚ line on the printed protractor (with the round surface facing zero)
3. Switch on Rayzer
4. Align single ray along 0˚ line to centre of block
5. Note the refracted ray is along the 180˚ line, which is the normal (0˚ to the surface)
6. Using the outer degree scale, move the protractor and D block (keep in place on 90-270˚ line) so the ray aligns along the 5˚ line
7. Note the refracted ray using the outer degree scale
8. Calculate the angle of refraction by subtracting 180 from this value
9. Repeat every 5˚ up to 40˚

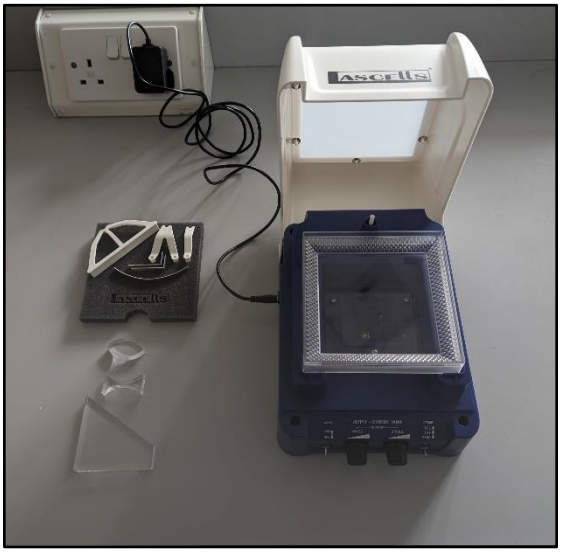
Waves

Ripple Tanks

Refraction and diffraction (with Lascells ripple tank)

Equipment list

Item	Quantity
Lascells ripple tank	1
Lascells ripple tank manual	1
Accessories pack	1



Procedure

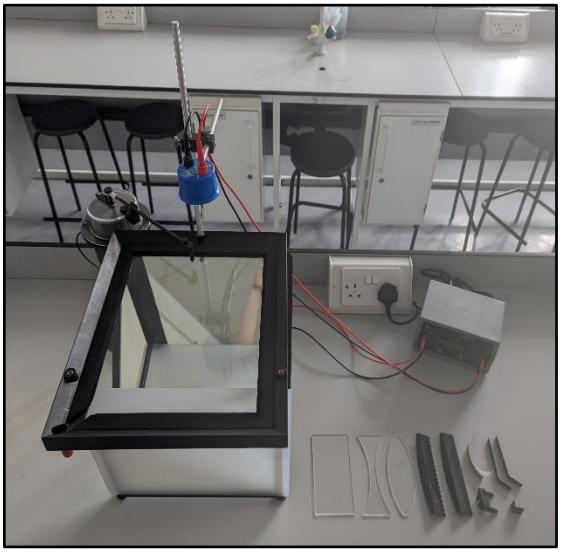
Use the ripple tank to investigate diffraction and refraction:

1. Use instruction manuals as required
2. Observe high and low wavelength waves
3. Observe small gaps and large gaps and indicate diffraction for both high and low wavelengths
4. Observe usefulness of ripple tank for refraction

Refraction and diffraction (with Eisco ripple tank)

Equipment list

Item	Quantity
Eisco ripple tank	1
Eisco ripple tank manual	1
Accessories pack	1



Procedure

Use the ripple tank to investigate diffraction and refraction:

1. Use instruction manuals as required
2. Observe high and low wavelength waves
3. Observe small gaps and large gaps and indicate diffraction for both high and low wavelengths
4. Observe usefulness of ripple tank for refraction