Mandatory Experiments

(Mechanics)

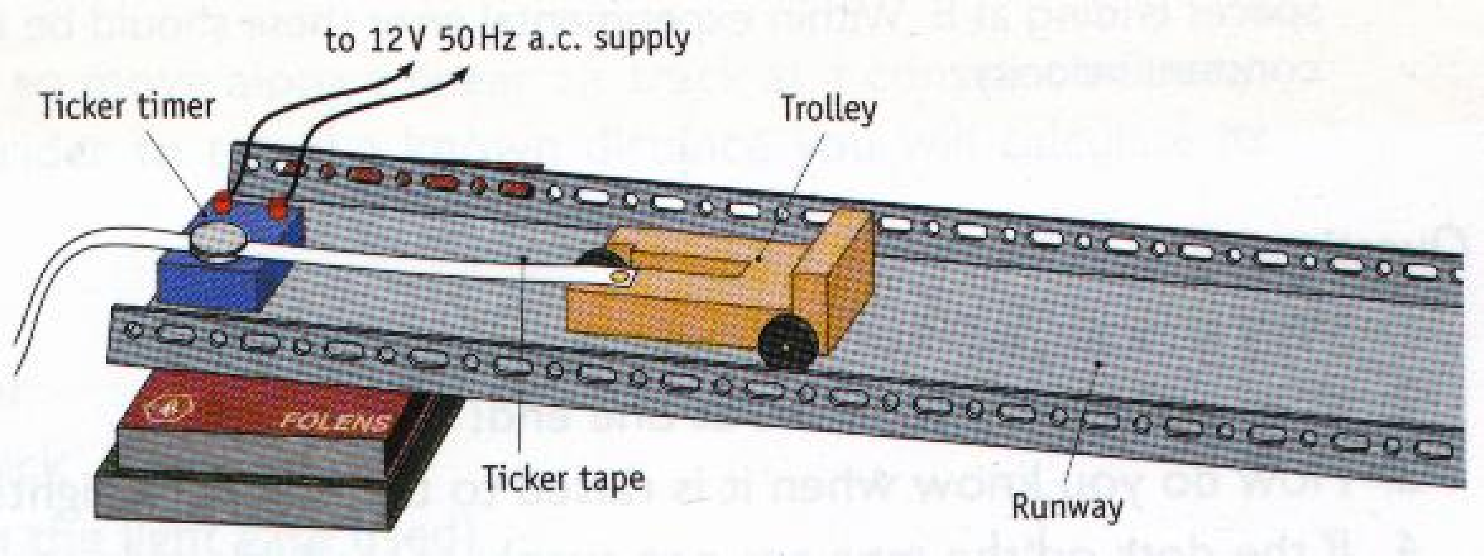
Mechanics 1A	Measure Velocity (TTT)
Mechanics 1A	Measure Velocity (ATT)
Mechanics 1B	Measure Acceleration (TTT)
Mechanics 1B	Measure Acceleration (ATT)
Mechanics 2	To Show $a \alpha F$
Mechanics 3	Conservation of Momentum
Mechanics 4	Measurement of *g*
Mechanics 5	Verify Boyle's Law
Mechanics 6	Laws of Equilibrium
Mechanics 7	Simple Pendulum (2)

Mechanics 1A (Method 1)

Measure Velocity (*TTT*)

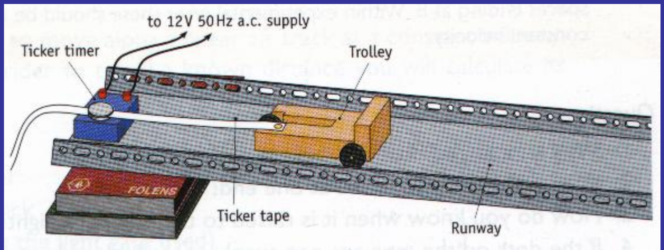
Velocity (TTT)

Apparatus



Track	Trolley	Ticker Tape Timer
Tape	A.C. Power Supply	Wedge

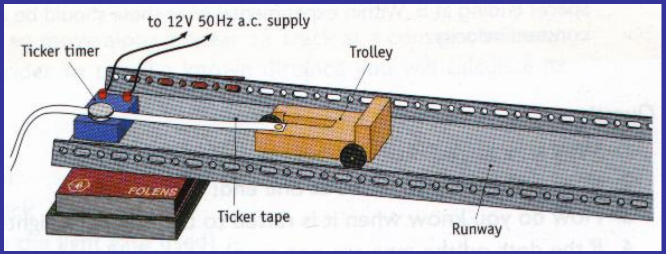
Velocity (TTT)



Procedure

- **Trolley moves at constant speed along the track** **(How do you know?)**
- **Measure (2) …**
- **How are these measured?**

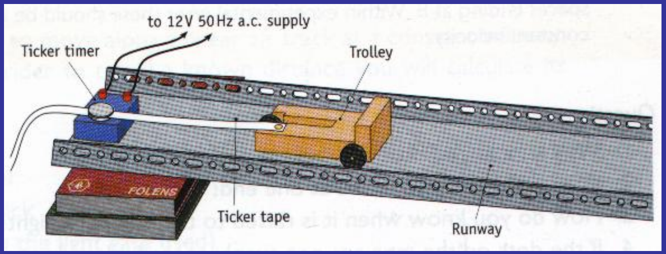
Velocity (TTT)

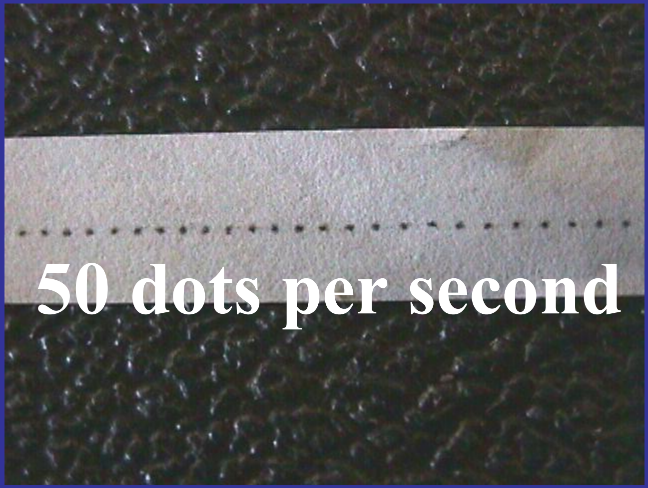


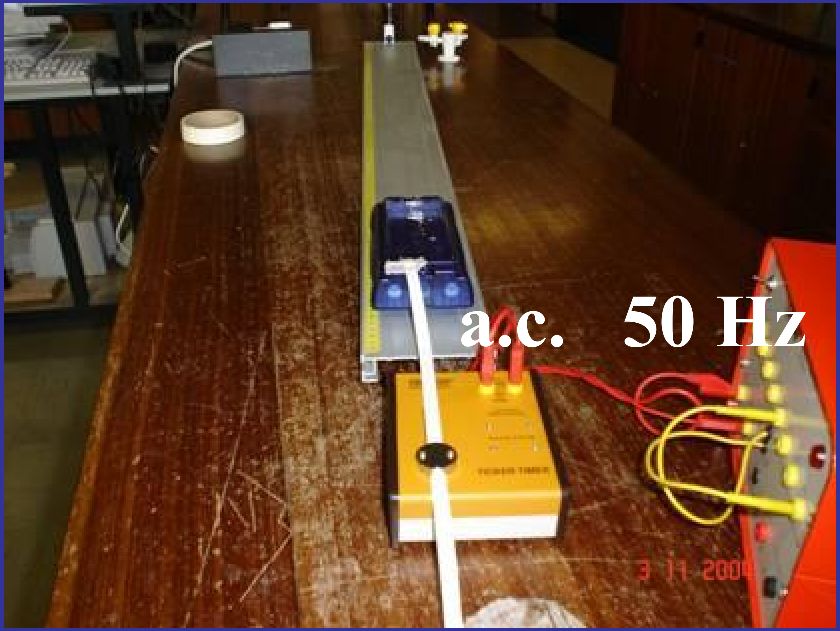
Procedure

- Trolley moves at constant speed along the track (How do you know?)
- Measure (2)
- … distance (spread of 10 spaces)
- … time (time for 10 spaces = 0.02 x 10)

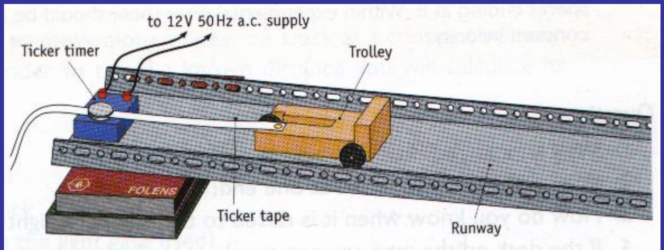
Velocity (TTT)







Velocity (TTT)



Procedure

$$Velocity = \frac{Spread\ of\ 10\ spaces}{10 \times 0.02}$$

Average Velocity

Velocity (TTT)

Precautions / Questions

1. Give two precautions taken to ensure an accurate result.
2. Why should you dust the runway.
3. Why should you oil the trolley wheels?
4. Why is the runway raised slightly at one end?
5. How do you know the trolley is moving at constant velocity?
6. How is friction reduced?
7. Why should you ignore the first five or six dots?
8. Why should pre-carbonated paper be used?

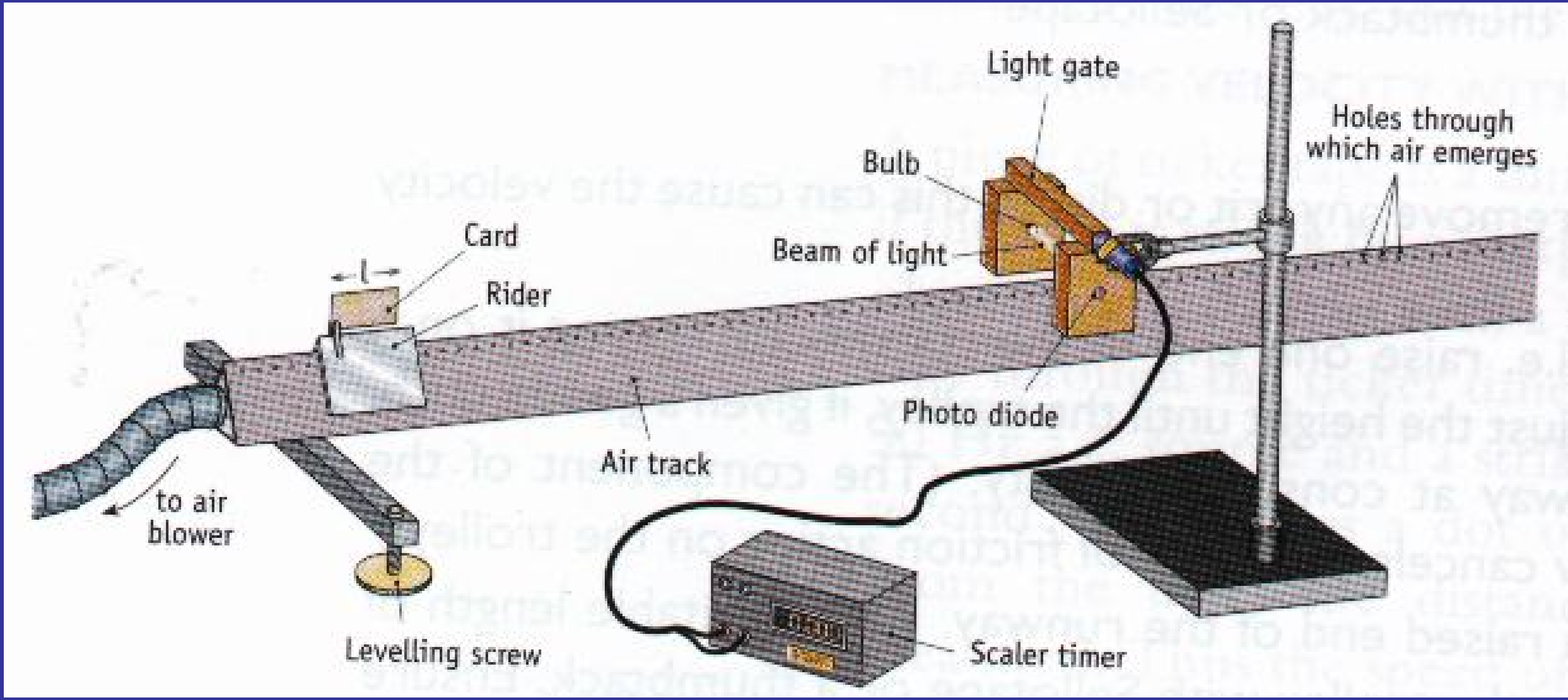
   (Answer: “Ticker timers that use pre-carbonated paper are recommended because the friction due to paper drag is reduced.)
9. Why is it better to measure for 20 spaces between dots than to measure for 10 spaces?
10. Avoid parallax error when using the metre stick.
11. Why should you repeat the measurements on another section of the tape?

Mechanics 1A (Method 2)

Measure Velocity (*ATT*)

Air Track Timer (Measure Velocity)

Apparatus

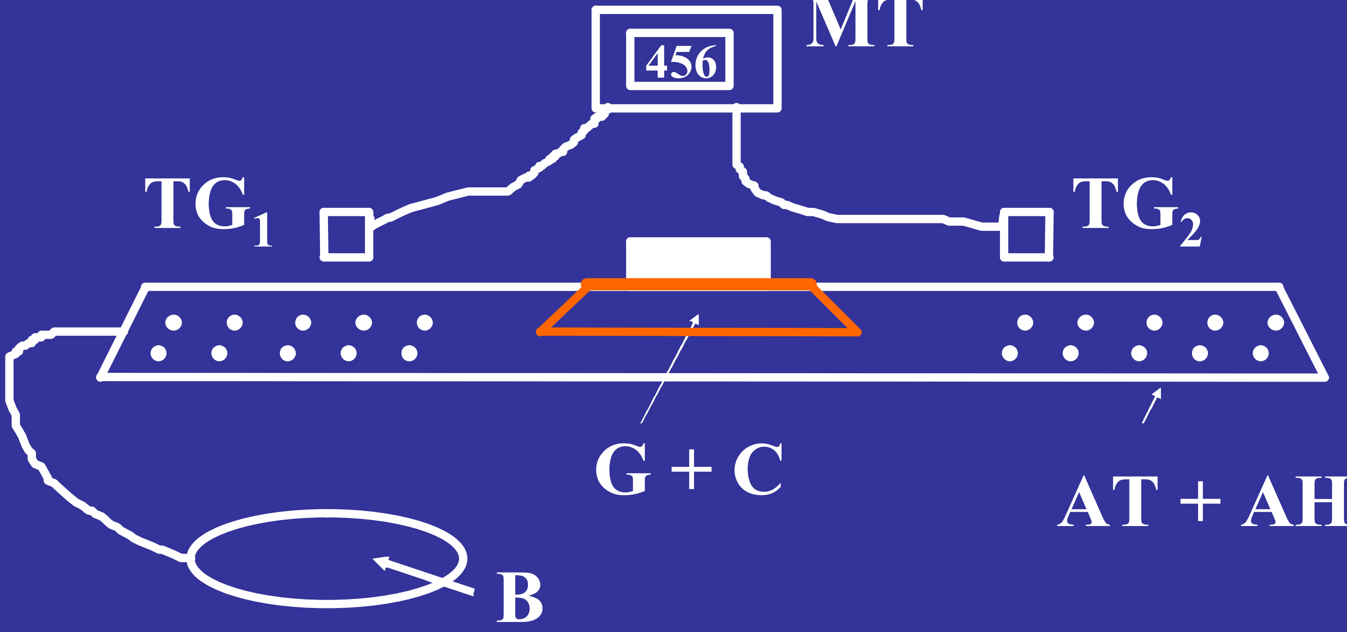


Air Track + Air Holes   Glider + Card   Timing Gates

Millisecond Timer   Blower

Velocity (ATT)

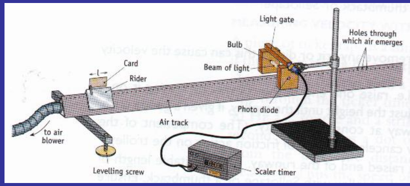
Apparatus

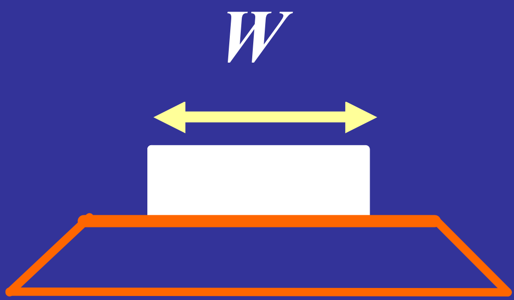


Air Track + Air Holes | Glider + Card | Timing Gates

Millisecond Timer | Blower

Velocity (ATT)





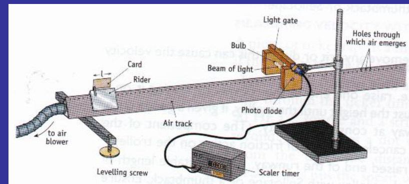
Procedure

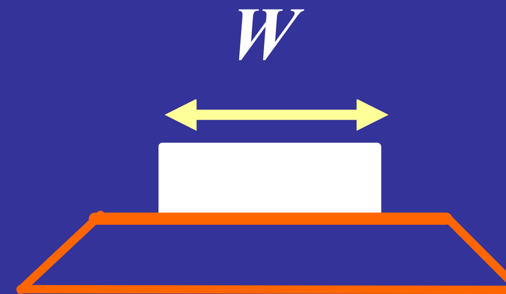
- Only one timing gate is needed.

  Zero the timer.

  Glider & card move through the timing gate, breaking the light beam.
- Measure (2) …
- How are these measured?

Velocity (ATT)





Procedure

- **Only one timing gate is needed.**

  Zero the timer.

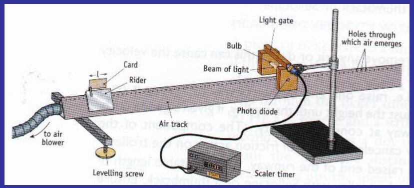
  Glider & card move through the timing gate, breaking the light beam.

- **Measure (2)**

  …width of card (*W*) with metre stick.

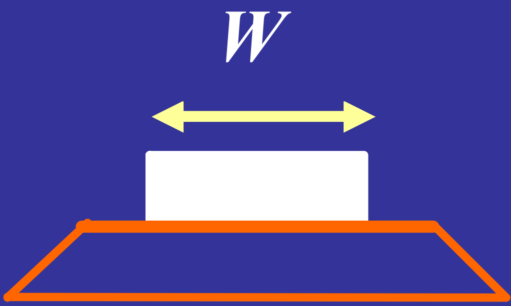
  … time from the timer

Velocity (ATT)



Results

$$Velocity = \frac{Width\ of\ card\ (W)}{Time\ from\ gate}$$



Velocity (ATT)

Precautions / Question

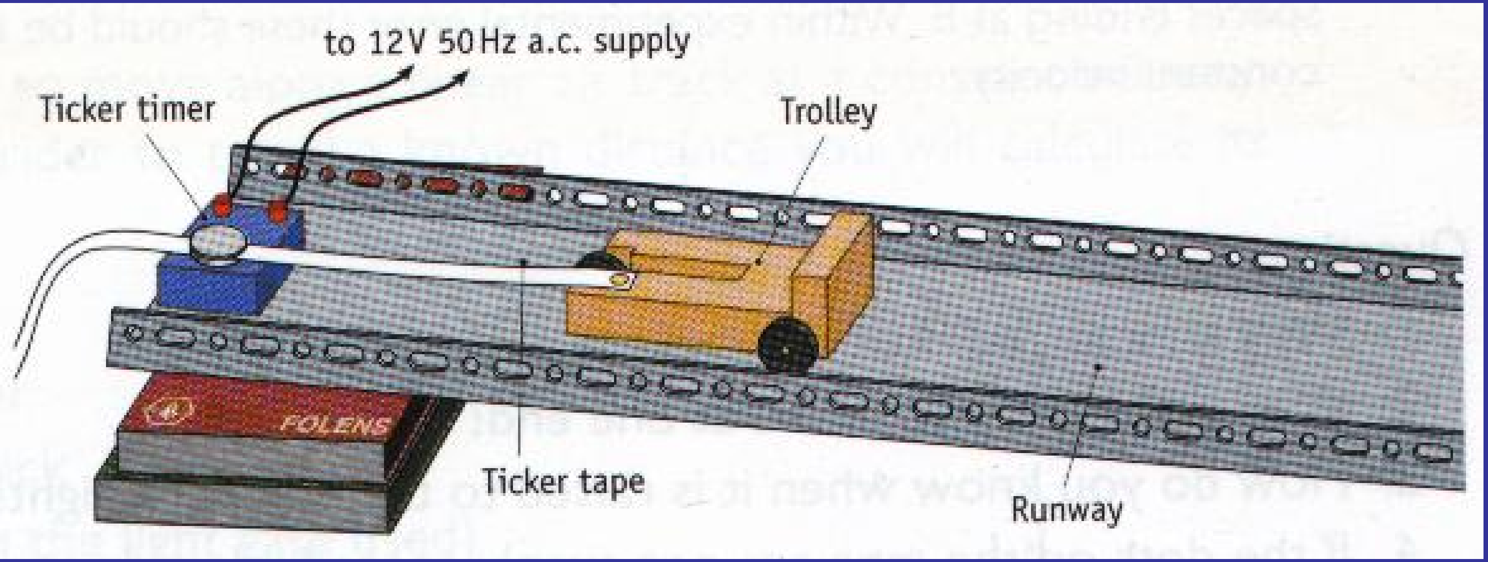
1. Level the track. (How would you check this?
2. Use two timing gates to check that the velocity is constant.
3. Give two precautions taken in this experiment to ensure an accurate result.
4. Why should you dust the runway and trolley wheels?
5. Give two methods for accelerating the trolley.
6. How do you know that the trolley is accelerating?
7. How is friction reduced?
8. Why should the two timing gates be well separated?
9. Why should *s* be large?
10. Why should the air supply be strong?
11. Why should the experiment be repeated?
12. Avoid parallax error when using the metre stick.
13. Etc.

Mechanics 1B (Method 1)

Measure Acceleration (*PTT*)

Acceleration (TTT)

Apparatus

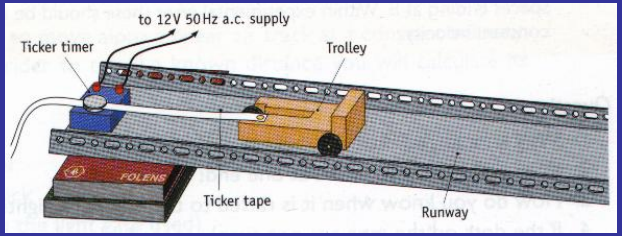


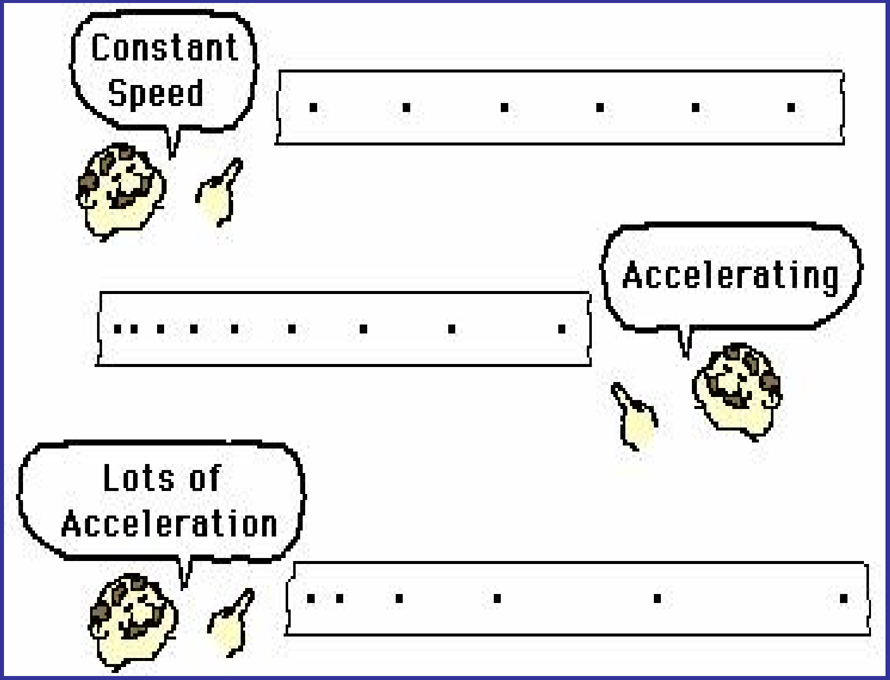
Track **Trolley** **Ticker Tape Timer**

Tape **A.C. Power Supply** **Wedge**

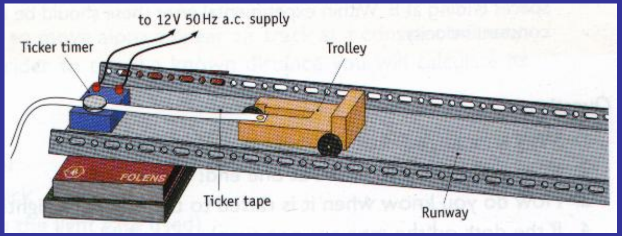
Method for causing acceleration (e.g. …)

Acceleration (TTT)





Acceleration (TTT)

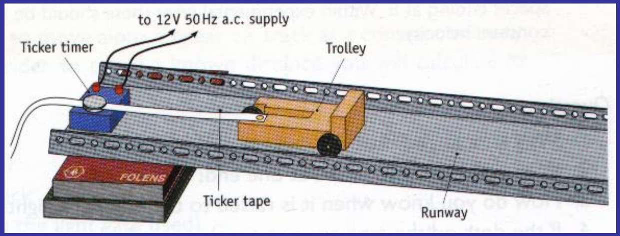


Two methods can be used:

use the equation $v = u + at$

or **use the equation** $v^2 = u^2 + 2as$

Acceleration (TTT)

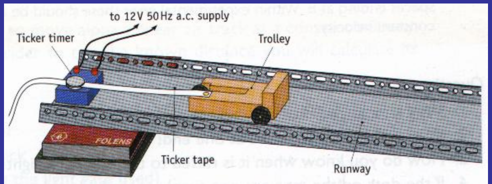


Procedure

$$Using:\ v = u + at$$

- Measure (3) …
- How are these measured?

Acceleration (TTT)

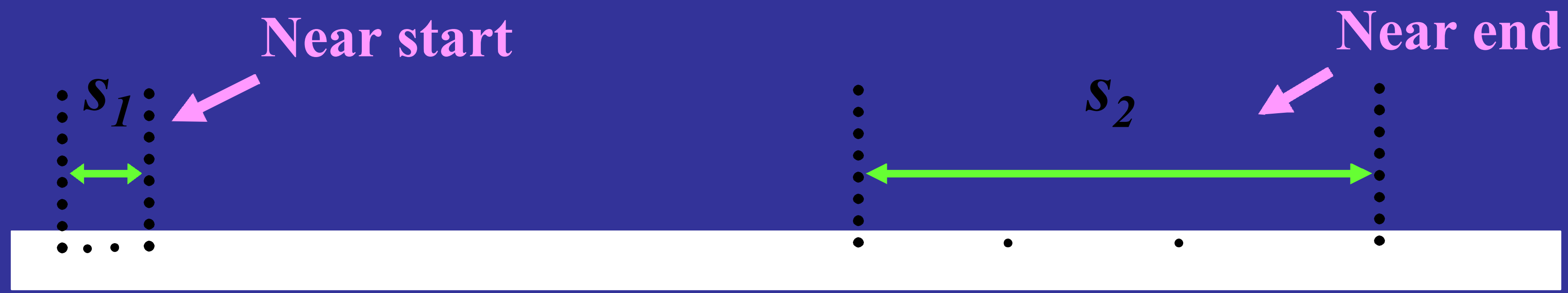


Procedure & Results

Using : $v = u + at$

Measure (3) … *u, v and t*

See below for how measured …



$$u = \frac{s_1}{3 \times 0.02}$$

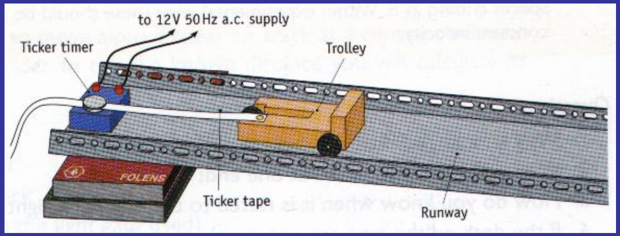
$$t = \text{“}n\text{”} \times 0.02$$

$$v = \frac{s_2}{3 \times 0.02}$$

“n” = no. of spaces from middle of “u” to middle of “v”

$$a = \frac{v - u}{t}$$

Acceleration (TTT)

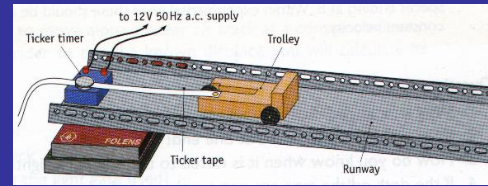


Procedure

Using : $v^2 = u^2 + 2as$

- Measure (3) …
- How are these measured?

Acceleration (TTT)

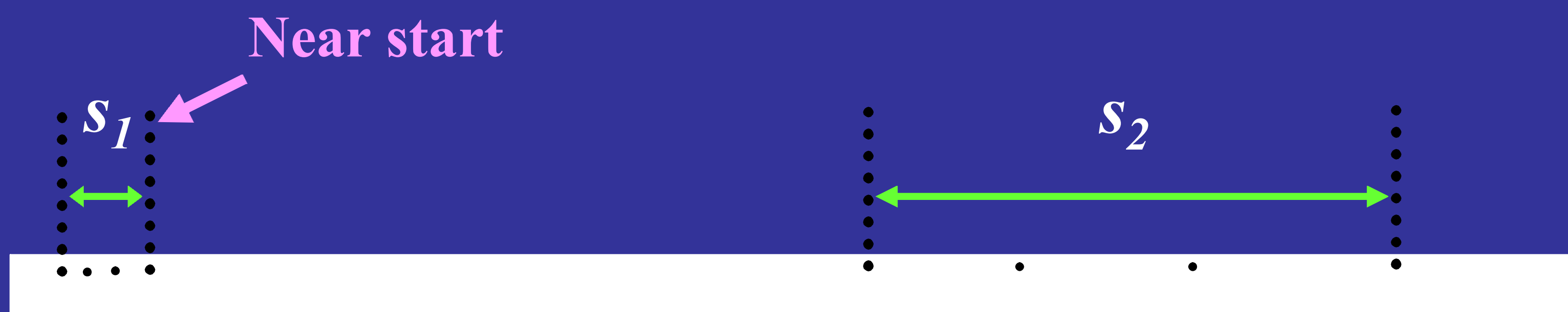


Procedure & Results

Using : $v^2 = u^2 + 2as$

Measure (3) … *u, v and s*

See below for how measured …



$$u = \frac{s_1}{3 \times 0.02}$$

$$v = \frac{s_2}{3 \times 0.02}$$

***s* = distance from "middle of *u*" to " middle of *v*"**

$$a = \frac{v^2 - u^2}{2s}$$

Acceleration (TTT)

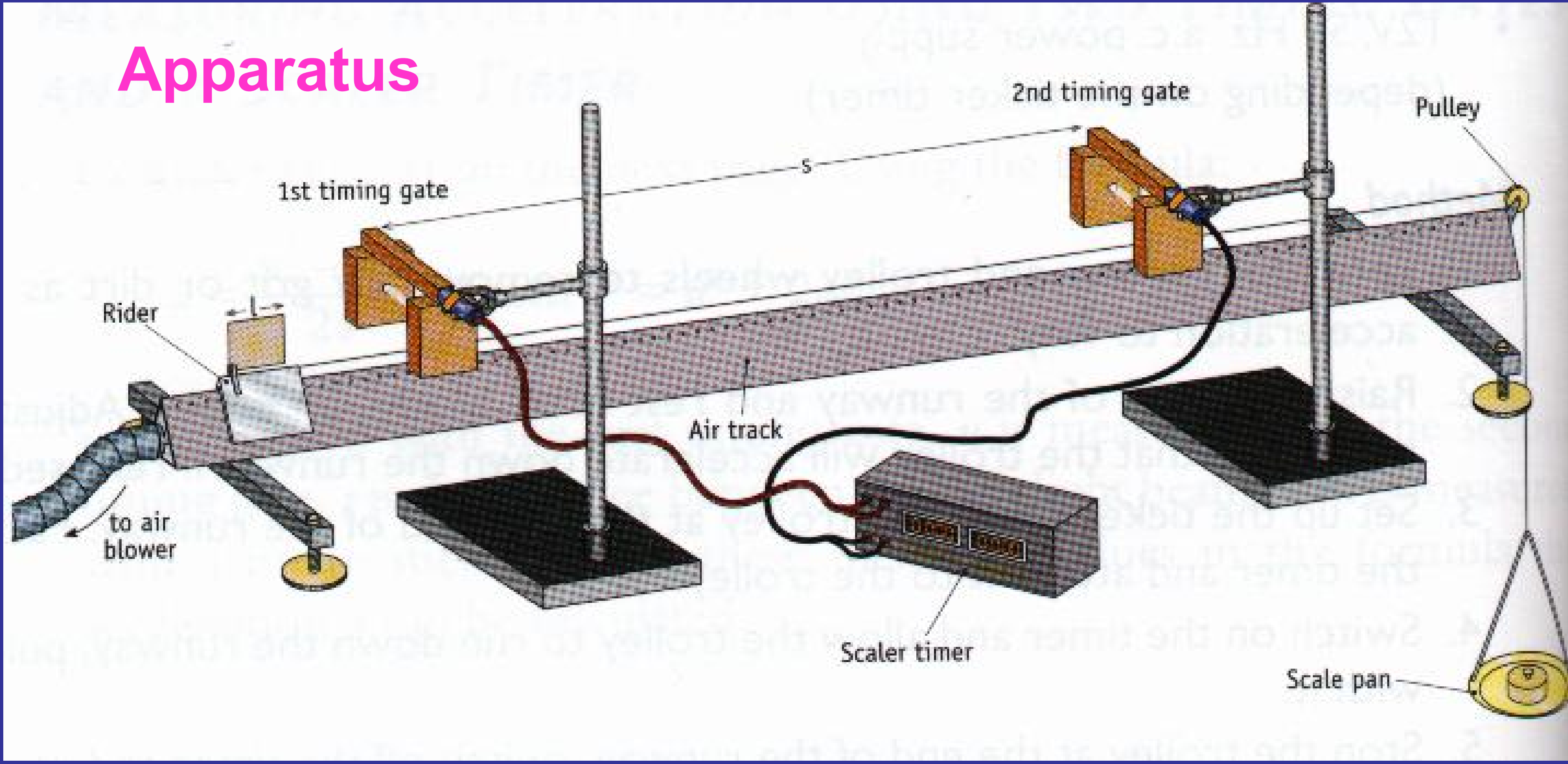
Precautions / Questions

1. Give two precautions taken in this experiment to ensure an accurate result.
2. Why should you dust the runway and trolley wheels?
3. Give two methods for accelerating the trolley.
4. How do you know that the trolley is accelerating?
5. How is friction reduced?
6. Why should the *u* and *v* dots be well separated?
7. Why should you ignore the first five or six dots?
8. Why should pre-carbonated paper be used?
9. When measuring for *u* or *v* why is it, (i) better, (ii) worse, to use 3 spaces than it is to use 5 spaces?
10. Why should the experiment be repeated?
11. Avoid parallax error when using the metre stick.
12. Etc.

Mechanics 1B **(Method 2)**

Measure Acceleration (*ATT*)

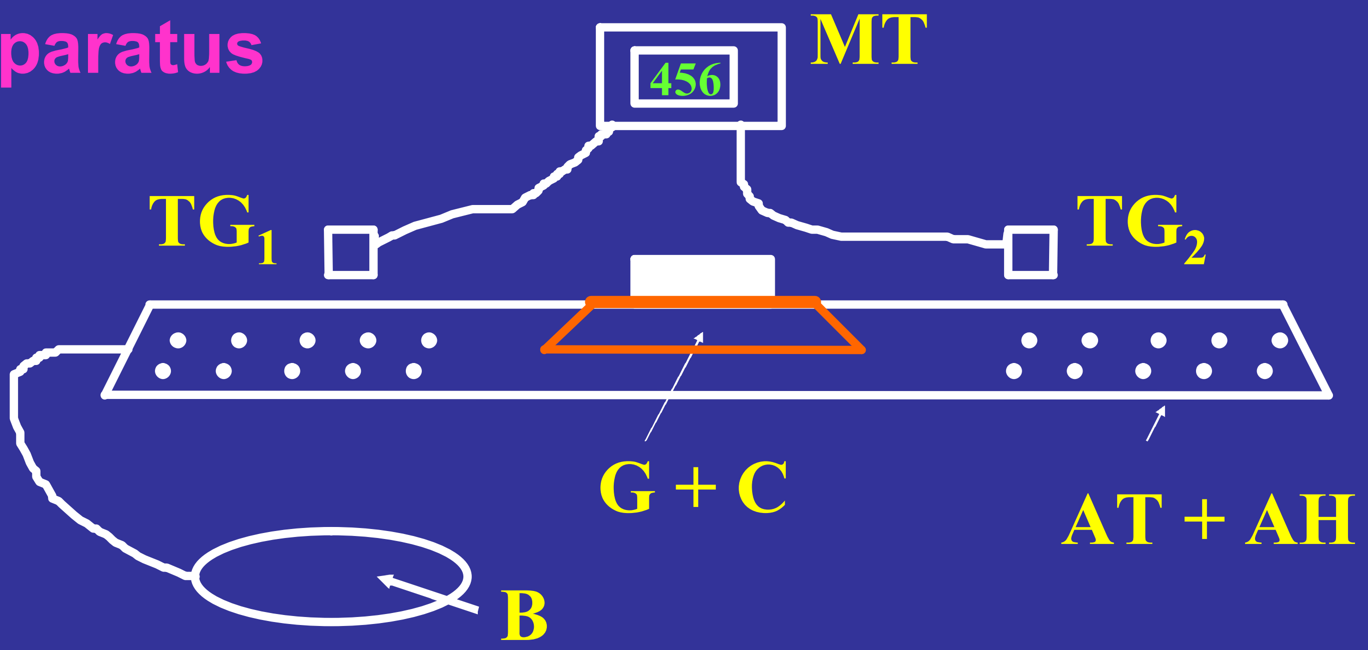
Air Track Timer (for acceleration)



Method for causing acceleration = ??

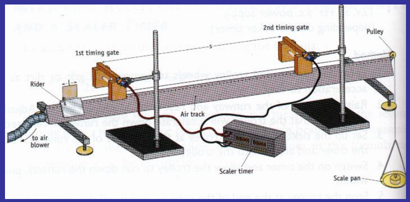
Acceleration (ATT)

Apparatus



Air Track + Air Holes	Glider + Card	Timing Gates
Millisecond Timer	Blower	Method for causing acceleration = ?

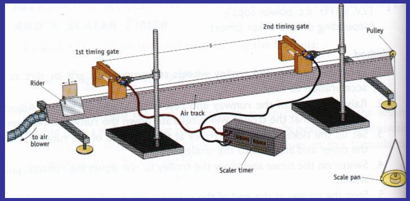
Acceleration (ATT)



Procedure

- Glider accelerates along the track with the card passing through both light gates …
- Measure (3) …
- How are these measured?

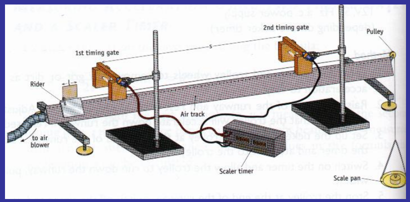
Acceleration (ATT)



Procedure

- Glider accelerates along the track with the card passing through both light gates …
- Measure (3) …
- How are these measured?

Acceleration (ATT)



Procedure & Results

$$v^2 = u^2 + 2as$$

Measure (3) … *u, v and s*

See below for how measured …

$$u = \frac{width\ of\ card}{time\ gate\ 1}$$

$$v = \frac{width\ of\ card}{time\ gate\ 2}$$

$$s = distance\ from\ gate\ 1\ to\ gate\ 2$$

$$a = \frac{v^2 - u^2}{2s}$$

Acceleration (ATT)

Precautions / Questions

1. Give two precautions taken in this experiment to ensure an accurate result.
2. Why should you dust the runway and trolley wheels?
3. Give two methods for accelerating the trolley.
4. How do you know that the trolley is accelerating?
5. How is friction reduced?
6. Why should the two timing gates be well separated?
7. Why should *s* be large?
8. Why should the air supply be strong?

10. Why should the experiment be repeated?
11. Avoid parallax error when using the metre stick.
12. Etc.

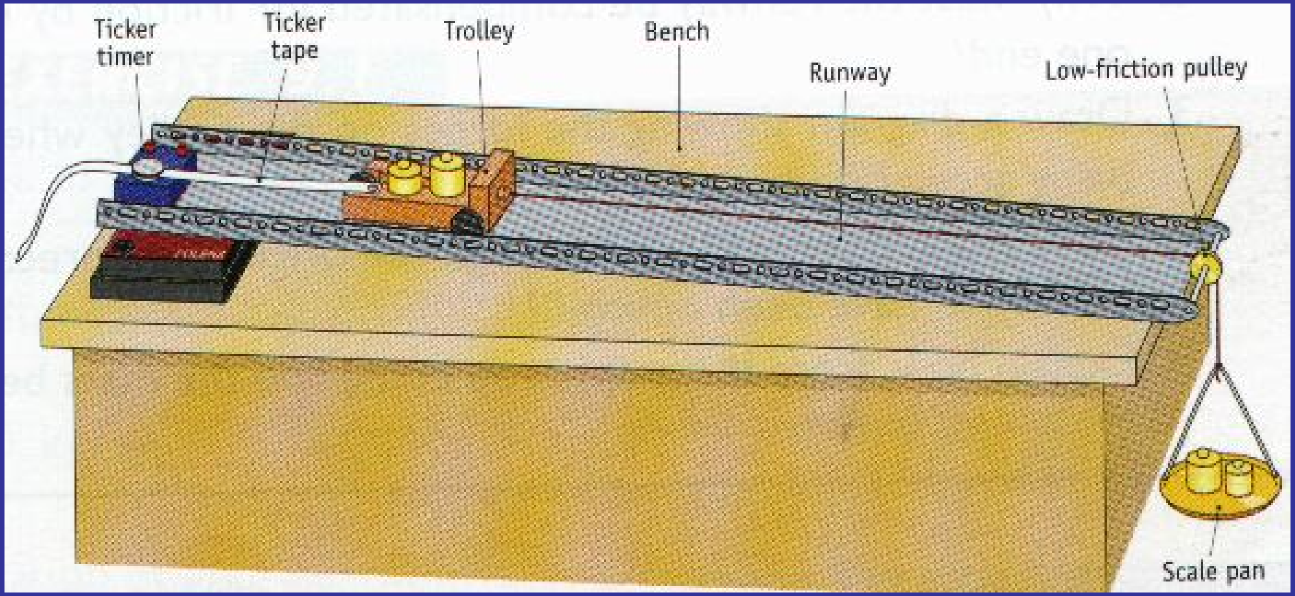
Mechanics 2

To Show that $a \propto F$

(To Verify Newton's 2nd Law)

Expt.: *a* α *F*

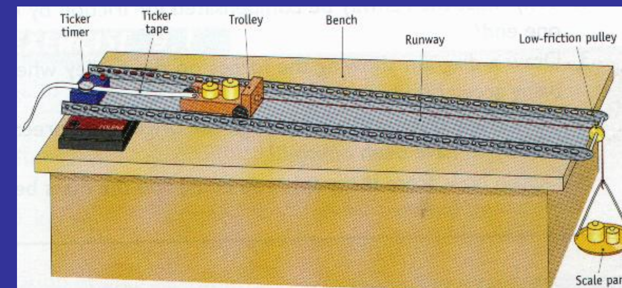
Apparatus

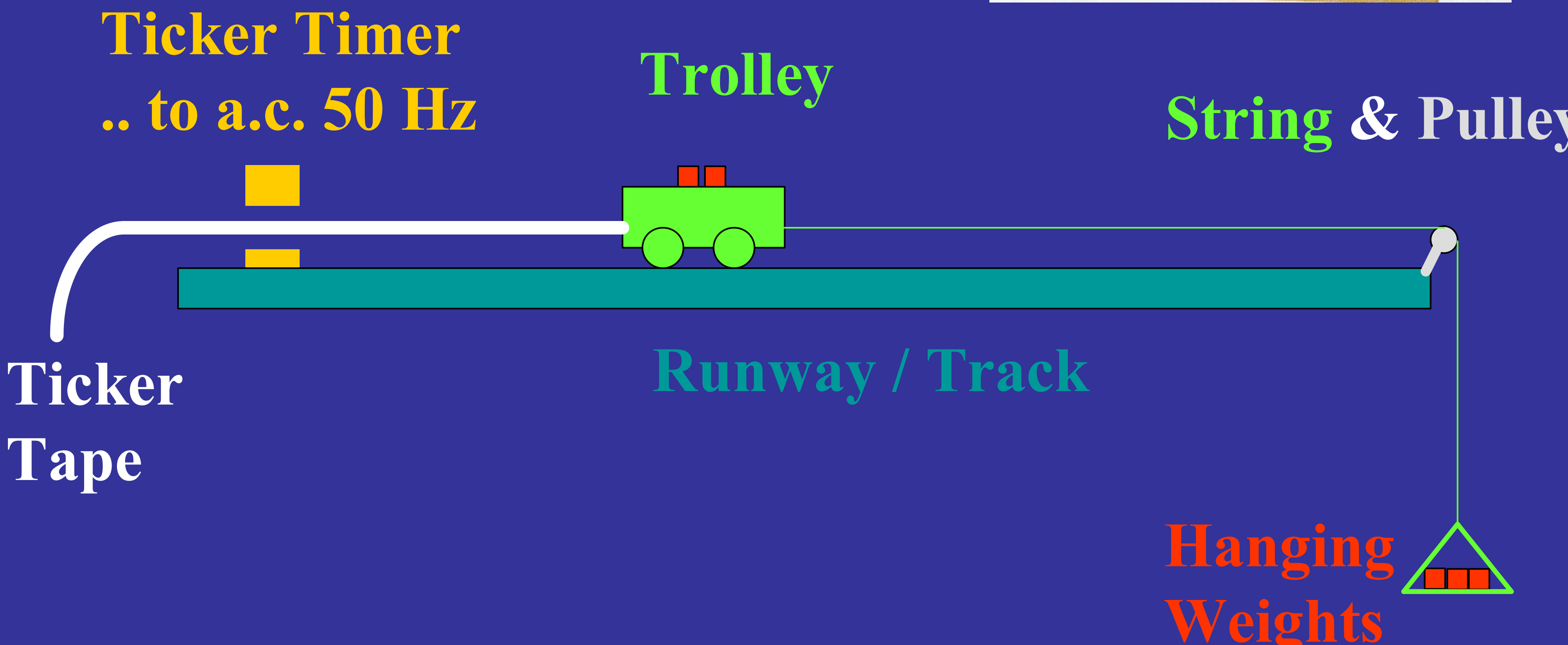


Track	Trolley	Ticker tape timer
A.C Power Supply	Tape	Hanging weights
String & Pulley	Wedge	

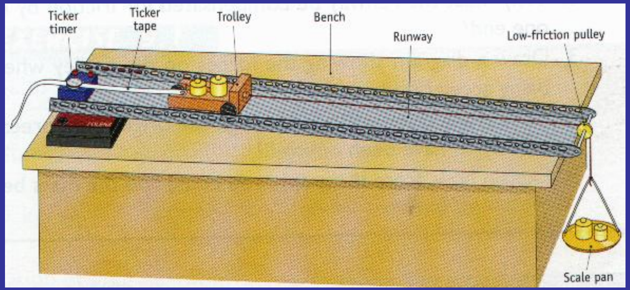
Expt.: $a \propto F$

Apparatus





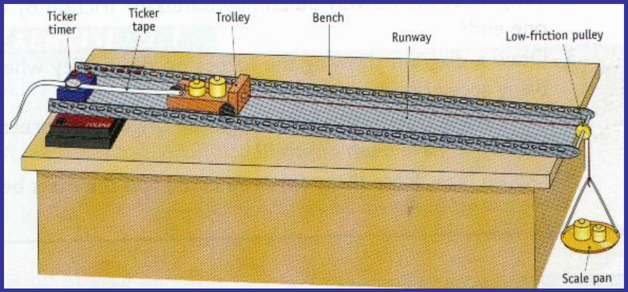
Expt.: $a \propto F$



Procedure

- Release trolley … accelerates … pattern of dots on .. Repeat using other weights in pan.
- Measure (2) …
- How are these measured?
- Repeat … other?? Why repeat?

Expt.: $a \propto F$



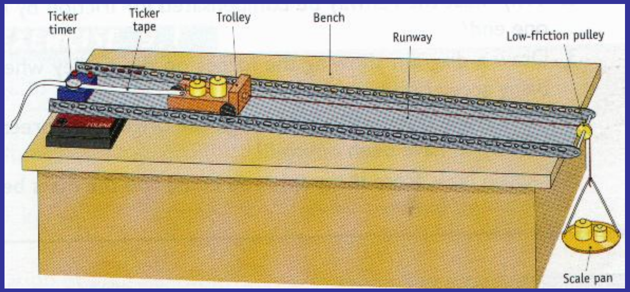
Procedure

- **Release trolley … accelerates … pattern of dots on .. Repeat using other weights in pan.**
- **Measure (2) … *a* *F***
- ***F* = hanging weights**

  ***a* is calculated using $v^2 = u^2 + 2as$ or $v = u + at$**

  (see TTT expt.)
- **Repeat … other *F*. Why repeat? … to graph.**

Expt.: $a \alpha F$



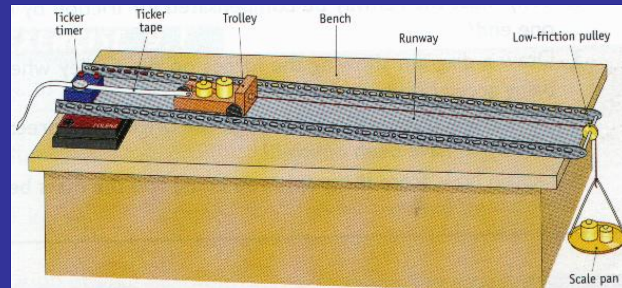
Results

Method 1

$$\frac{a}{F} = a\ constant$$

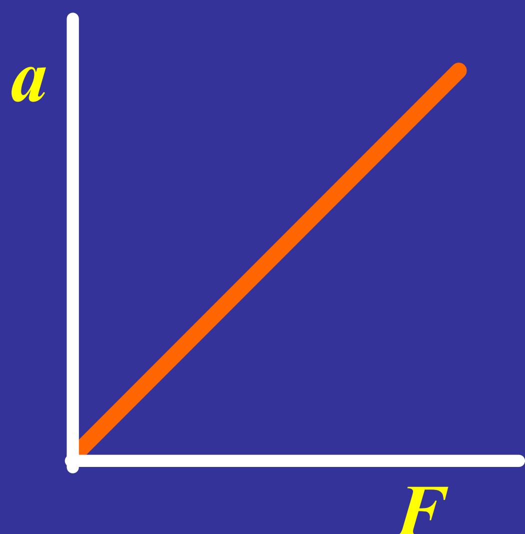
$$\Rightarrow a \ \alpha \ F$$

Expt.: $a \alpha F$



Results

Method 2 (better)



"SLTO"

$$\Rightarrow a \alpha F$$

Expt.: *a* α *F*

Precautions / Questions

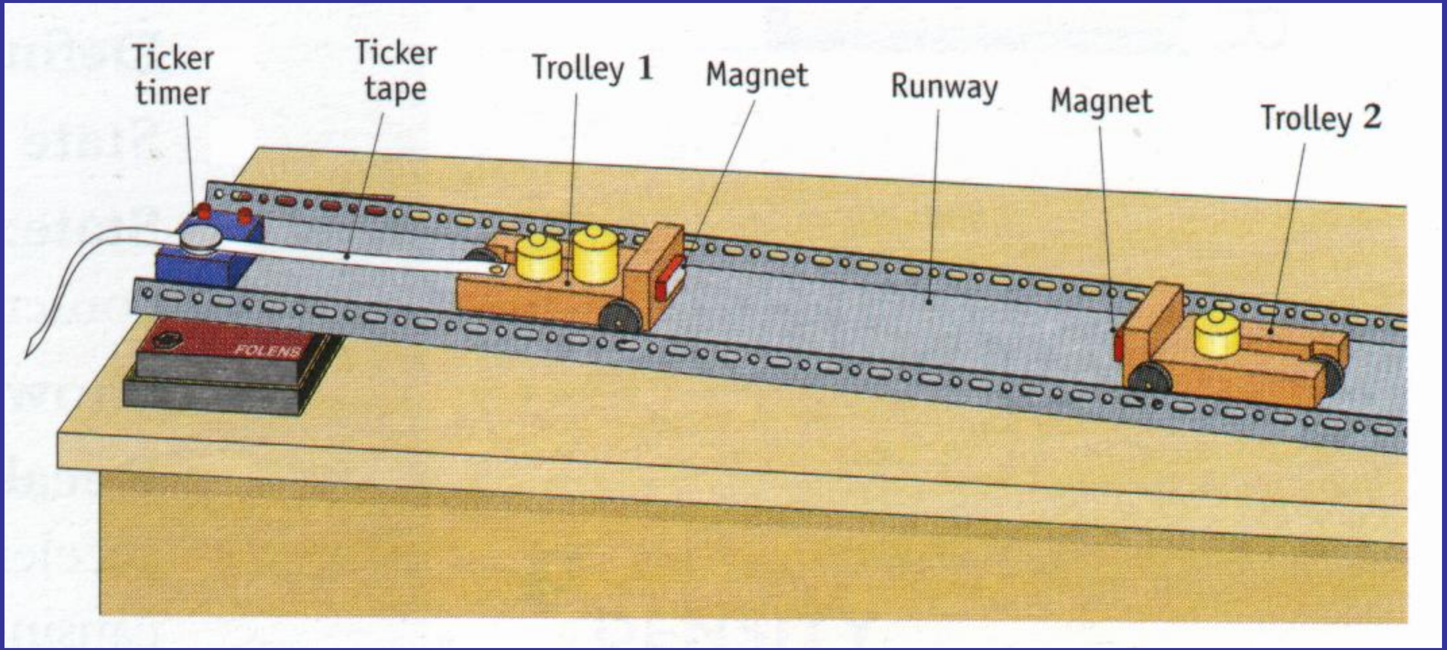
1. Give two precautions taken to ensure an accurate result.
2. Why must the masses be transferred from the trolley to the scale pan and vice versa?
3. How do you reduce friction?
4. How do you compensate for friction?
5. How is mass kept constant?
6. Draw a diagram showing the forces on the trolley.
7. How is mass measured from the result graph?
8. Why are the *u* and *v* patches well separated?
9. Give two methods for applying the force.
10. Which gives a constant, multiplying or dividing *a* and *F*?

Mechanics 3

To Verify the Principle of Conservation of Momentum

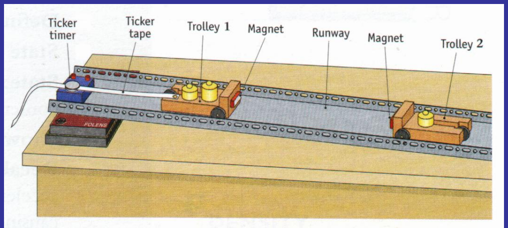
Conservation of Momentum

Apparatus



Track	Trolleys x2	Magnets
Ticker tape timer	A.C Power Supply	Tape
Wedge	Masses	

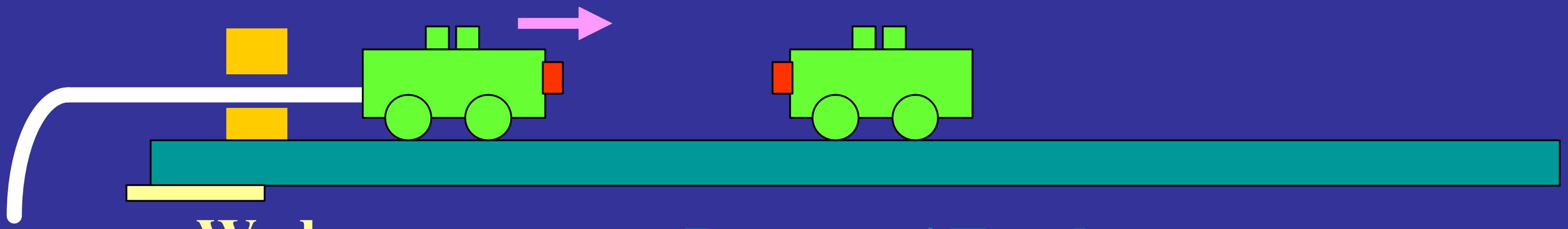
Conservation of Momentum



Apparatus

Ticker Timer
.. to a.c. 50 Hz

Trolleys
with Magnets



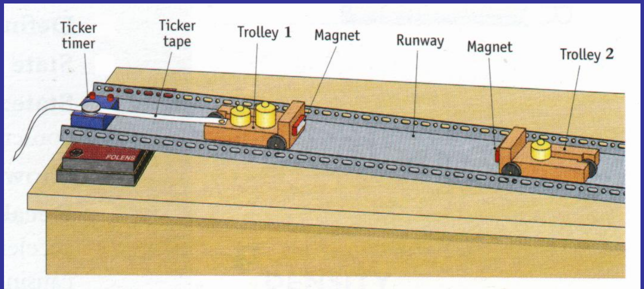
Ticker Tape

Wedge

Runway / Track

Track	Trolleys x2	Magnets
Ticker tape timer	A.C Power Supply	Tape
Wedge	Masses	

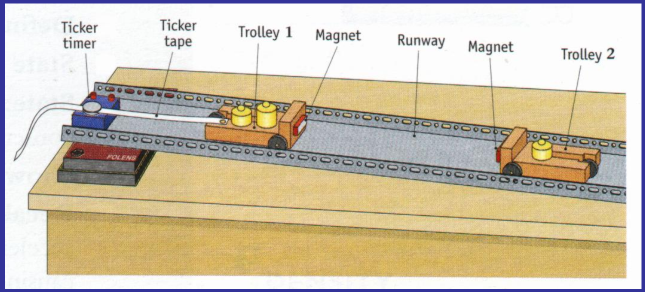
Conservation of Momentum



Procedure

- Trolley 1 moving … Trolley 2 stopped
  Collide … stick … and move on together.
- Measure (4) …
- How are these measured?
- Repeat … other …   Why repeat?

Conservation of Momentum



Procedure

- Trolley 1 moving … Trolley 2 stopped
  Collide … stick … and move on together.
- Measure (4) … m_i m_2 u_1 v
- m_1, m_2 using electric balance

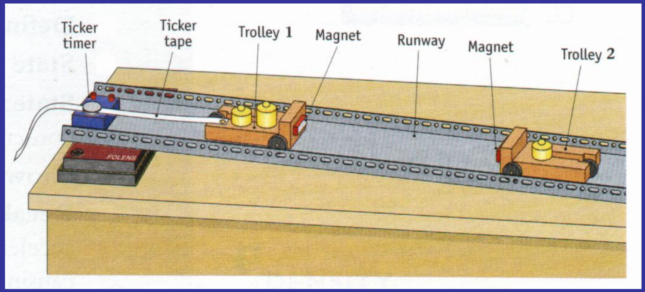
$$u_1 = \frac{\text{spread of 10 spaces}}{10 \times 0.02} \qquad \text{for trolley1}$$

$$v = \frac{\text{spread of 10 spaces}}{10 \times 0.02} \qquad \text{for joined trolleys}$$

- Repeat adding masses to trolleys.

  Why? To show the law works for all masses and all velocities.

Conservation of Momentum



Momentum before = Momentum after

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m_1u_1 = (m_1 + m_2)v$$

Conservation of Momentum

Precautions / Questions

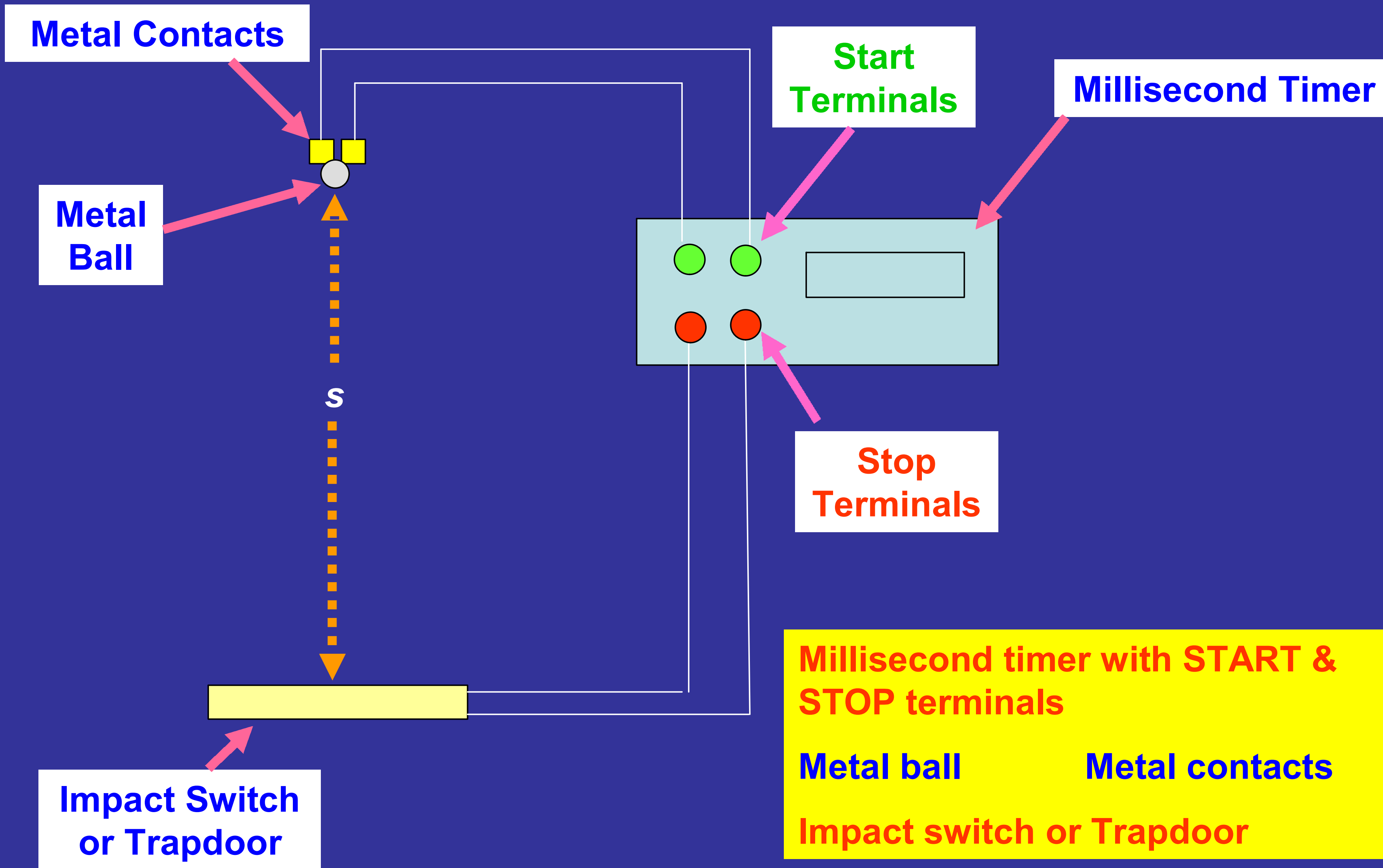
1. Give two precautions taken in this experiment to ensure an accurate result.
2. Why should you dust the runway and trolley wheels?
3. Why is the runway raised slightly at one end?
4. How do you know that the trolley is moving at constant velocity?
5. How is friction reduced?
6. When measuring velocity why is it better to use 20 spaces than to use 10 spaces?
7. Why should you ignore the first five or six dots?
8. Why should pre-carbonated paper be used?
9. Give two methods for getting the trolleys to stick together on collision.
10. Why should you measure velocities immediately before and immediately after the collision?
11. If magnets are used in the experiment, why is it that the forces they exert do not change the momentum of the system?
12. Give one method used to avoid having external forces.
13. Avoid parallax error when using the metre stick.

Mechanics 4

Measure Acceleration due to Gravity (Free-fall)

g by free-fall

Apparatus



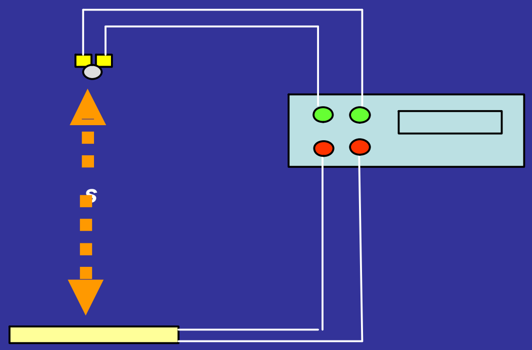
Millisecond timer with START & STOP terminals

Metal ball

Metal contacts

Impact switch or Trapdoor

g by free-fall



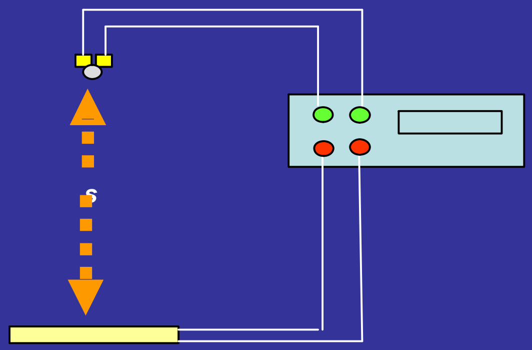
Procedure

- Release ball. It falls freely. Timer starts automatically.

  Timer stops automatically when ball hits the trapdoor.

  Repeat several times for same height.
- Measure (2) …
- How are these measured?
- Repeat … other … Why repeat?

g by free-fall



Procedure

- Release ball. It falls freely. Timer starts automatically.

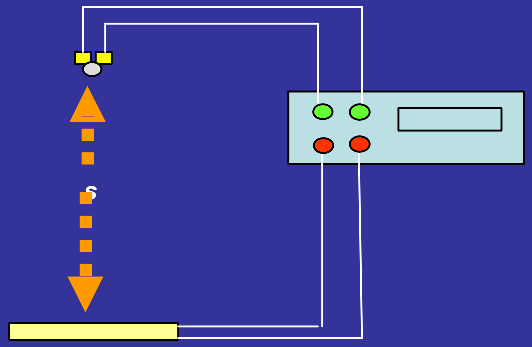
  Timer stops automatically when ball hits the trapdoor.

  Repeat several times for same height.
- Measure (2) … height (s) and time (t)
- s = distance from bottom of ball to top of trapdoor

  t = smallest time recorded for that height
- Repeat for other heights.

  Why repeat? … to get average g *or* to graph.

g by free-fall



Results

$$s = u\,t + \tfrac{1}{2}\,a\,t^2$$

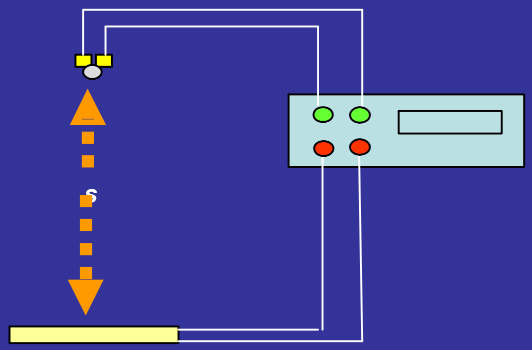
$$s = 0 + \tfrac{1}{2}\,g\,t^2$$

$$\Rightarrow g = \frac{2s}{t^2}$$

Calculate average g

or ...

g by free-fall



Results

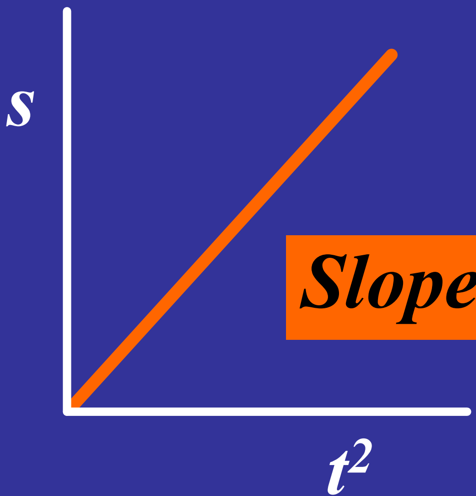
$$s = u\,t + \tfrac{1}{2}\,a\,t^2$$

$$s = 0 + \tfrac{1}{2}\,g\,t^2$$

$$s = (\tfrac{1}{2}\,g)\,t^2$$

| | |

$$y = m\,x$$



Slope $= \tfrac{1}{2}g$

$g =$ *slope x 2*

g by free-fall

Precautions / Questions

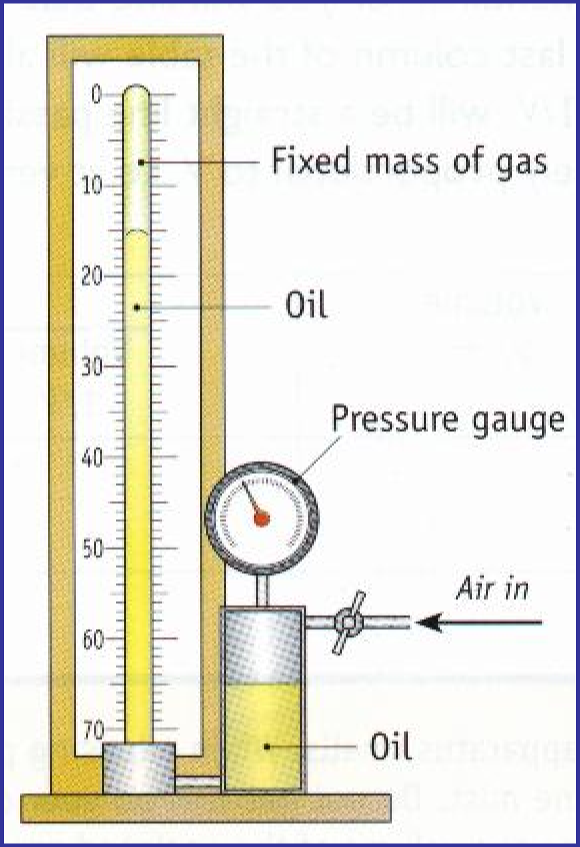
1. Give two precautions taken to ensure an accurate result.
2. Why is each height repeated five or six times?
3. For a given height which time should be used, the smallest time or the average time? Why?
4. Give two reasons why is it better to drop the ball through larger heights?
5. Why is it better to place a piece of paper between the ball and electromagnet? (*if that is what you are using)*
6. Why should the trapdoor be loosely held by the magnet?
7. Why is the ball dropped from different heights?
8. From what part of the ball is height measured?
9. Which is better, a centisecond timer of a millisecond timer? Why?
10. What external forces might act on the ball while it is falling? How are these reduced?
11. Avoid parallax error when using the metre stick.

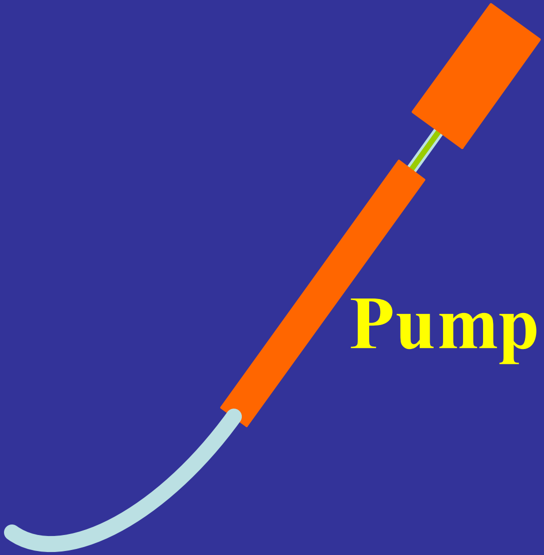
Mechanics 5

Verify Boyle's Law

Boyle's Law

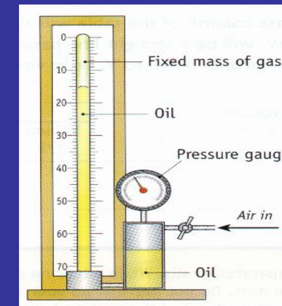
Apparatus





Closed tube (top)	**Air at the top**
Oil & reservoir	**Pump**
Pressure Gauge	**Volume Scale**
Tap	

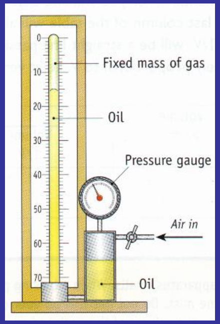
Boyle's Law



Procedure

- Apply different pressures .. (pump & tap) and take readings.
- Measure (2) …
- How are these measured?
- Repeat …other… Why repeat?

Boyle's Law



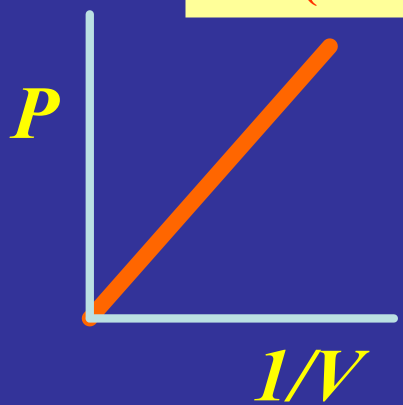
Procedure

- Apply different pressures .. (pump & tap) and take readings.
- Measure (2) … *P & V*
- *P* is read from the pressure gauge
  V is read from the volume scale
- Repeat …other pressures.
  Why repeated? … to graph

Boyle's Law

Results

Method 1
(better)



"SLTO"

$\Rightarrow P \propto 1/V$

Method 2

$PV = a\ constant$

$\Rightarrow P \propto 1/V$

Boyle's Law

Precautions / Questions

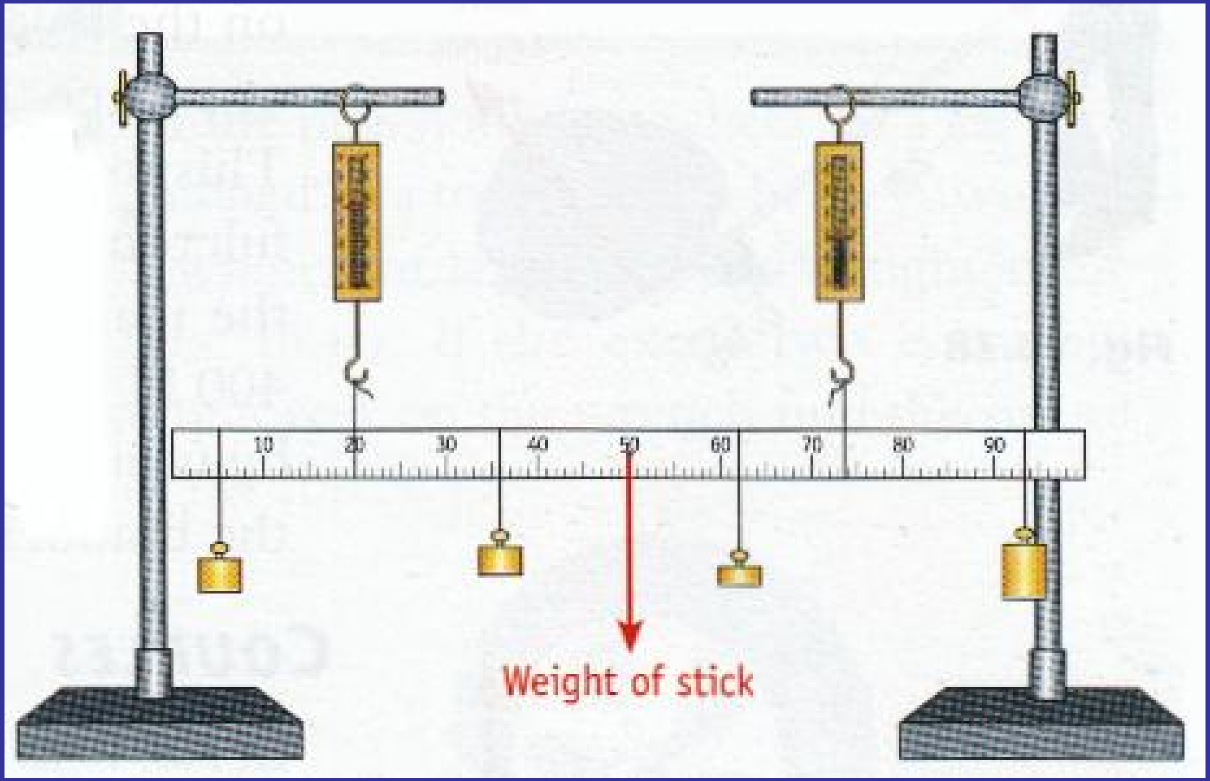
1. Give the main precaution taken to ensure an accurate result.
2. Why do you wait 2 minutes between readings?
3, Why should you release the gas slowly?
4. What should give a constant, multiplying or dividing P and V?
5. What equation results from this law?
6. Avoid parallax error when reading the volume and pressure scales.

Mechanics 6

Laws of Equilibrium

Laws of Equilibrium

Apparatus



Metre Stick

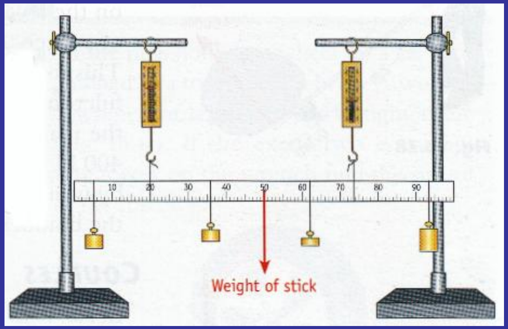
Newton Spring Balances x2

Weights x4

Retort Stand

String

Laws of Equilibrium



Procedure

- Find the centre of gravity (by hanging from one string).

  Assemble as shown and adjust … for equilibrium.
- Measure the weight of metre stick (*W*).

  Record weight of each weight (*W1, W2, W3, W4).*

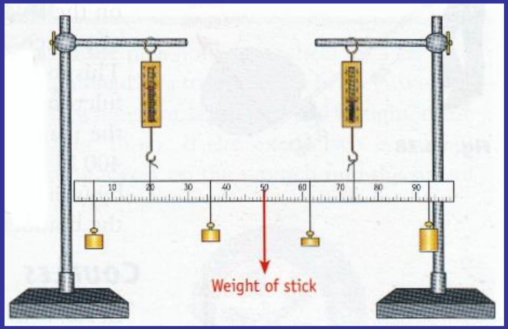
  Record each spring balance reading (*R1, R2*) .

  Record the weights using a spring balance.

  Choose some point to take moments about.

  Record distance of each above (7) from this point..
- Repeat … other weights/positions …

Laws of Equilibrium



Results

1. Forces up = Forces down

$$R1 + R2 = W + W1 + W2 + W3 + W4$$

2. About any point,

Sum of clock. moments = Sum of anticlockwise moments

e.g. about 0 cm …

$$R_1.d_1 + R_2.d_2 = W.x + W_1.x_1 + W_2.x_2 + W_3.x_3 + W_4.x_4$$

Laws of Equilibrium

Precautions / Questions

1. Give two precautions taken to ensure an accurate result.
2, Why must the metre stick be balanced horizontally?
3. Give a good method for checking that the metre stick is horizontal.
4. Why should the Newton-spring-balances be hanging vertically?
5. If the metre stick was not horizontal why is it likely that the measurements of distance that you took are incorrect?
6. Is it weights or masses that you measure in this experiment?
7. How do find the centre of gravity of the metre stick?

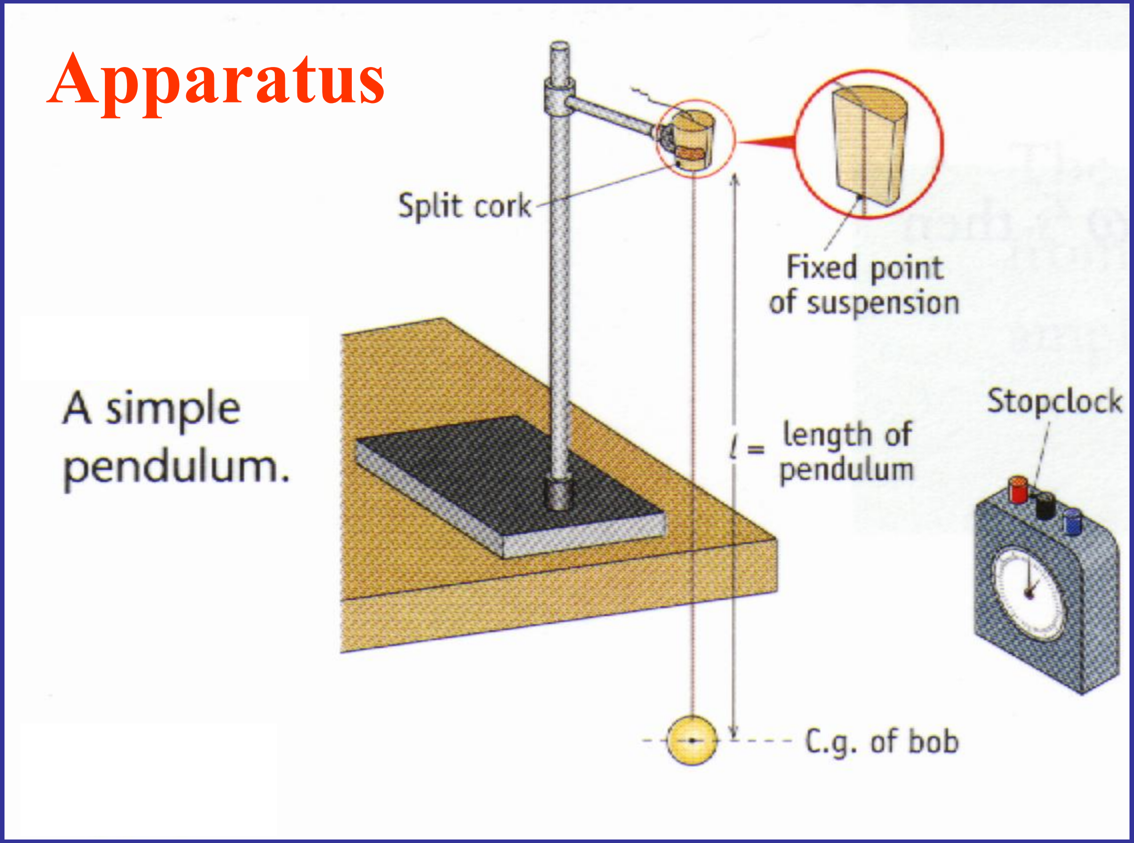
Mechanics 7

Simple Pendulum

(i) Relationship between Period and Length

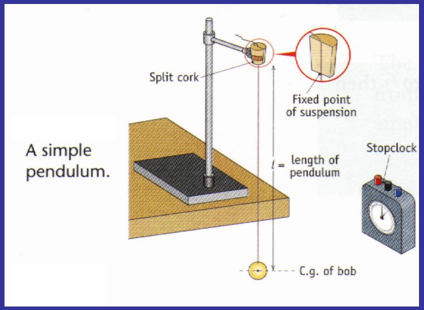
(ii) Hence Calculation of *g*

Simple Pendulum



Bob	Split Cork (point support)
String	Stopwatch

Simple Pendulum

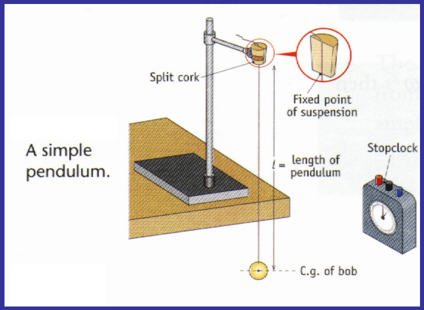


Procedure

- Time 30 swings (*t*) … small angle (< 5°).

  Repeat for other lengths (*L*).
- Measure (2) …
- How are these measured?
- Repeat .. other ... Why repeated?

Simple Pendulum



Procedure

- **Time 30 swings (*t*) … small angle (< 5°).**

  Repeat for other lengths (*L*).

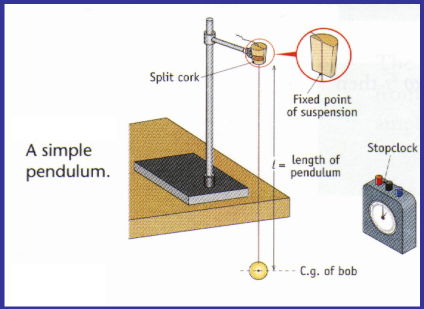
- **Measure (2) … period (*T*) length (*L*)**

- ***T = t ÷ 30***

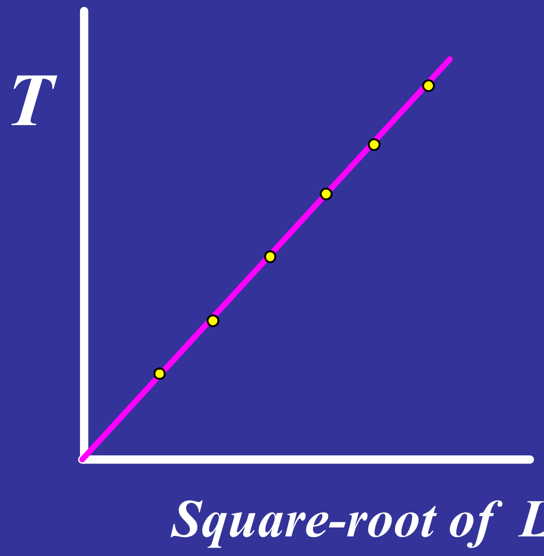
  ***L* .. from point support to centre of bob = (l_S + *r*)**

- **Repeat .. other *L* .. (i) to graph to show relationship,**
  (ii) to get *g* from graph
  (iii) to get average *g*

Simple Pendulum



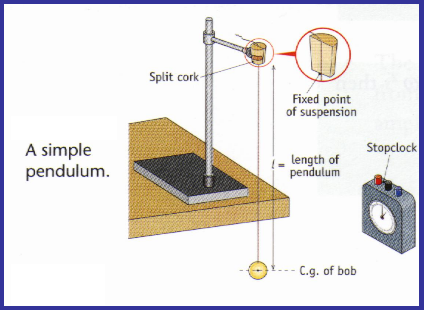
Results (to show relationship)



"SLTO" ➔ *T* α Square-root of *L*

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Simple Pendulum



Results (to calculate *g* – Method 1)

$$T = 2\pi\sqrt{\frac{L}{g}}$$

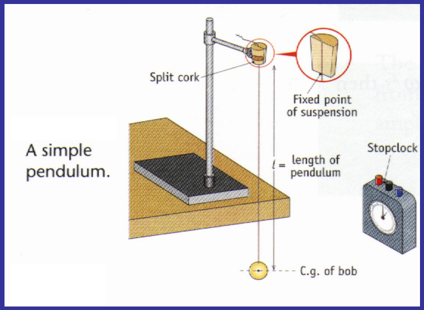
$$T^2 = 4\pi^2 \frac{L}{g}$$

→

$$g = 4\pi^2 \frac{L}{T^2}$$

Calculate average g

Simple Pendulum



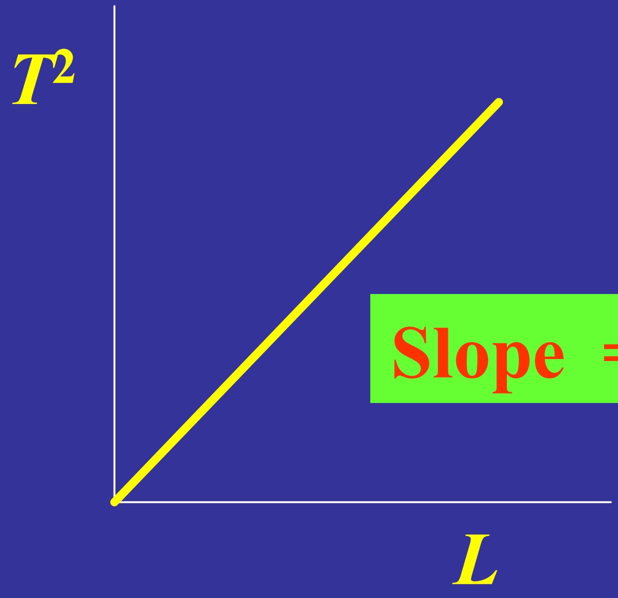
Results (to calculate g – Method 2)

or **Graph**

$$T^2 = 4\pi^2 \frac{L}{g}$$

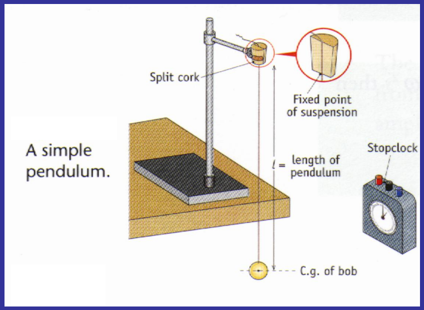
$$T^2 = \left(\frac{4\pi^2}{g}\right) L$$

$$y = m \quad x$$



Slope = $4\pi^2 / g$

Simple Pendulum



Precautions / Questions

1. Give two precautions taken to ensure an accurate result.
2. Between what points is the length measured?
3. The pendulum should have a point support. How do you do this?
4. Why should you get a more accurate value for *g* with a longer length pendulum?
5. Why must the angle of swing be small (< 5°)?
6. Why is it more accurate to time 50 swings rather than 10 swings?
7. For calculating *g*, why is the experiment repeated for different lengths?
8. The amplitude decreases slightly as the pendulum swings. Why does this not affect the results?
9. The pendulum bob should not spin and the pendulum should not rotate.
10. Avoid parallax error when using the metre stick.