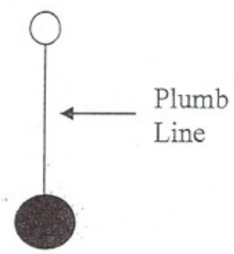
# Experiment 1

The Centre of Gravity of an object is that point at which all of its weight appears to be concentrated.
In this experiment you will find the Centre of Gravity of an irregularly shaped object made from a thin piece of card.




The Centre of Gravity is directly in line with the string.

1. Take the irregular shaped object and write your name and Science class on one side of the card.
2. Use one of the holes (A) in the card to hang it on the nail so that it can swing freely.
3. Loop the plumb line to the nail and mark the line of the string (AX) on the card.
4. Repeat steps 2 and 3 for hole B to obtain line BY.
5. The Centre of Gravity is where AX and BY intersect.
6. Confirm the position of the Centre of Gravity by hanging the object from a third point.

A. Identify a possible source of error in this exercise.

________________________________________

________________________________________

________________________________________

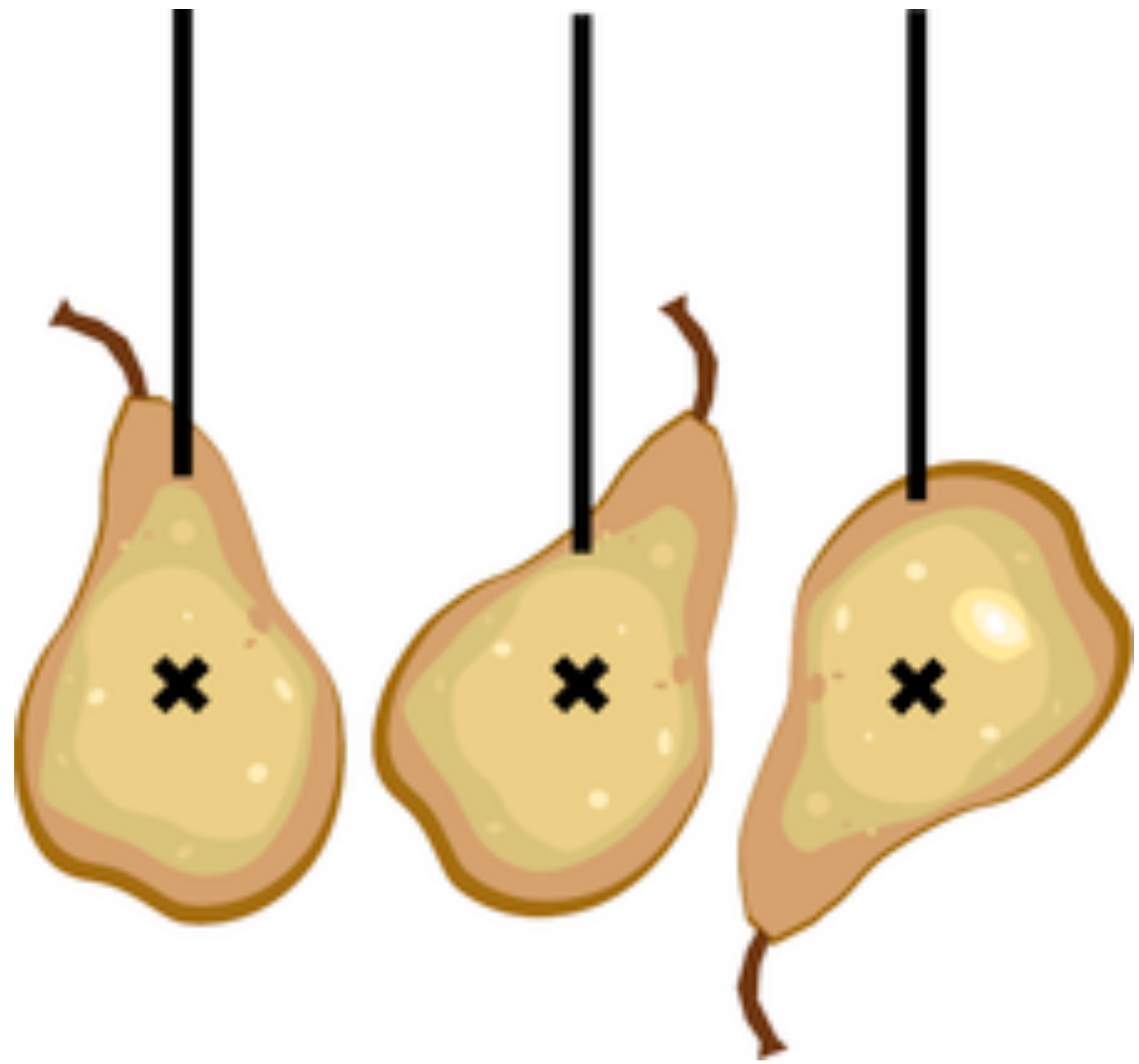
B. How could you improve your accuracy?

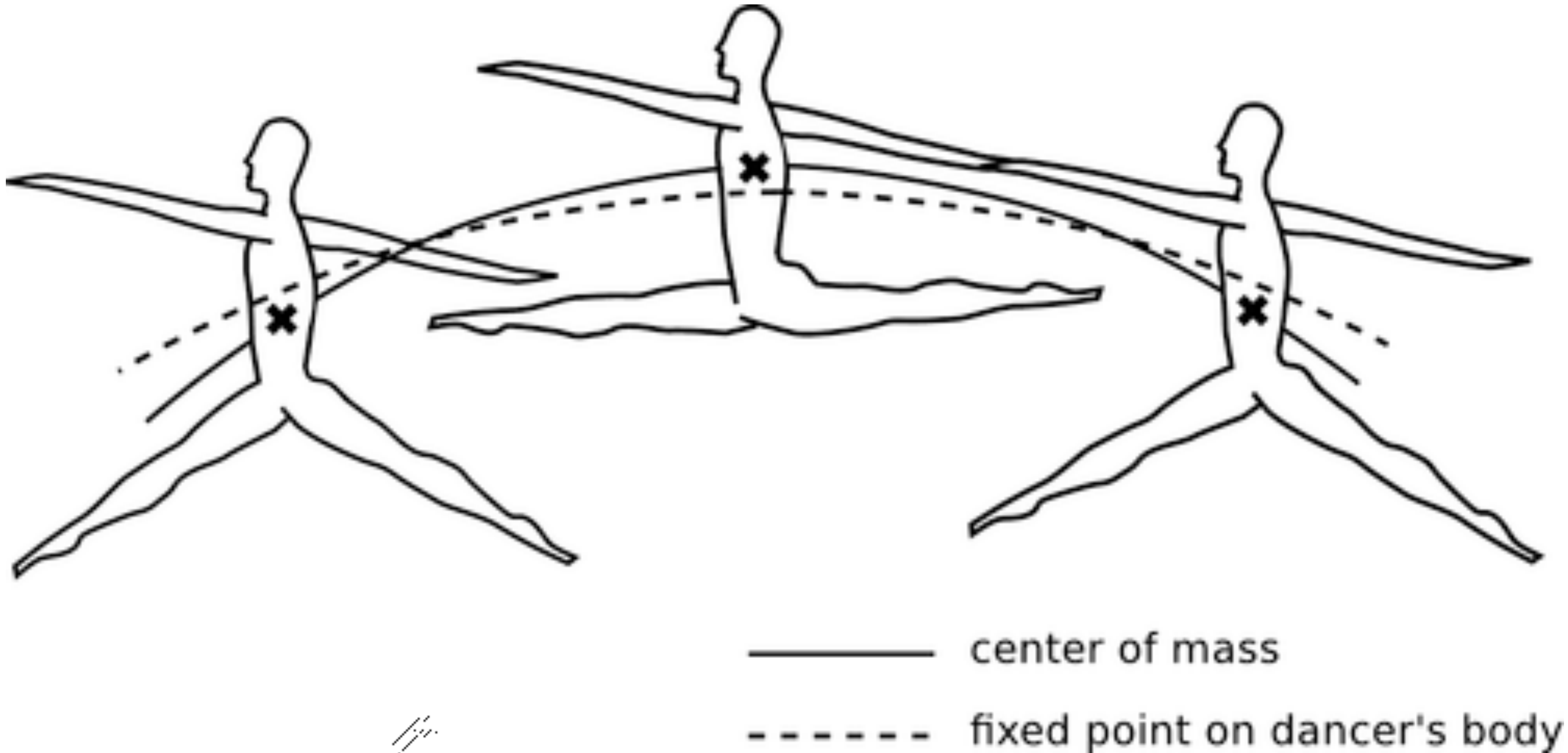
________________________________________

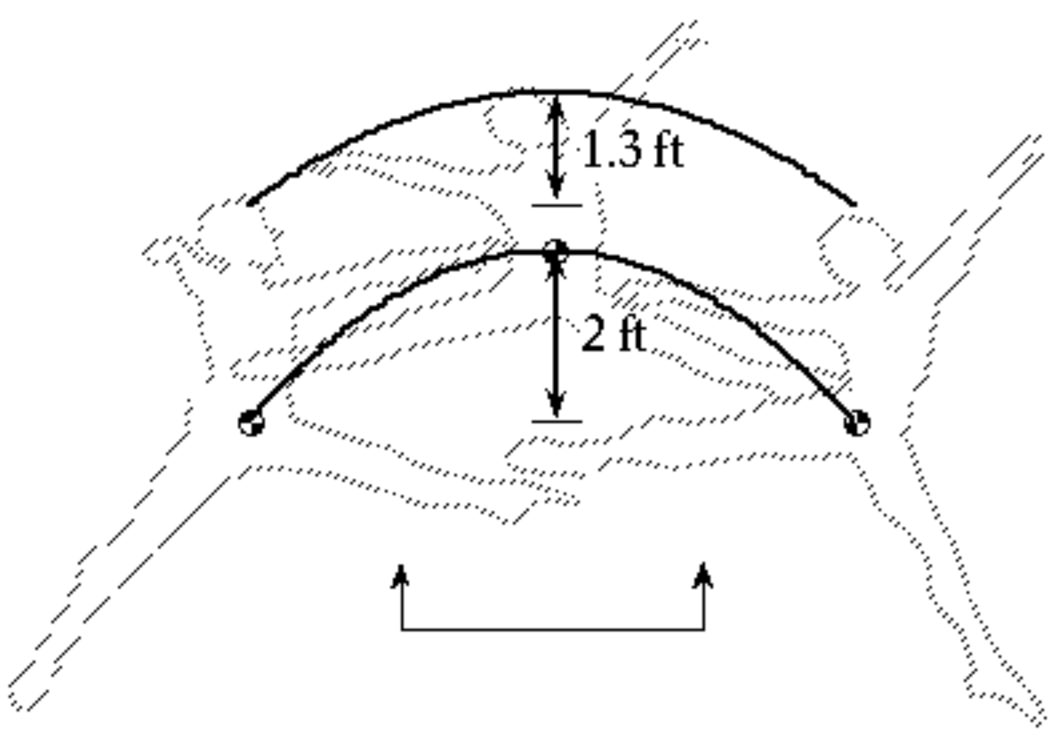
________________________________________

________________________________________

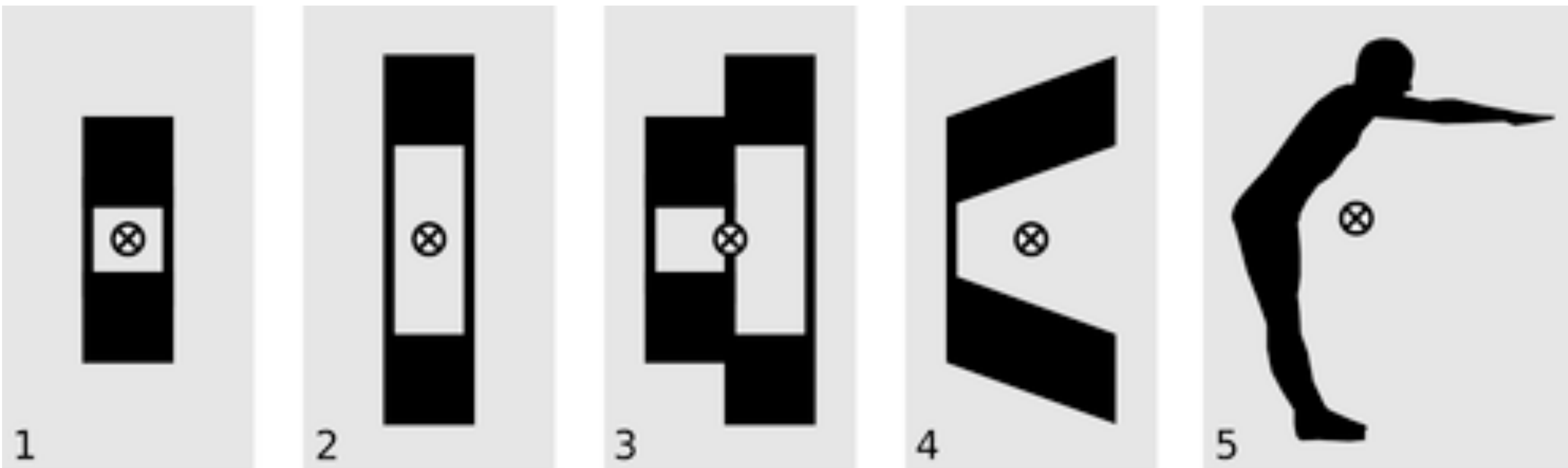
7. Find the Centre of Gravity of the L shape. Write your name and Science class on it.



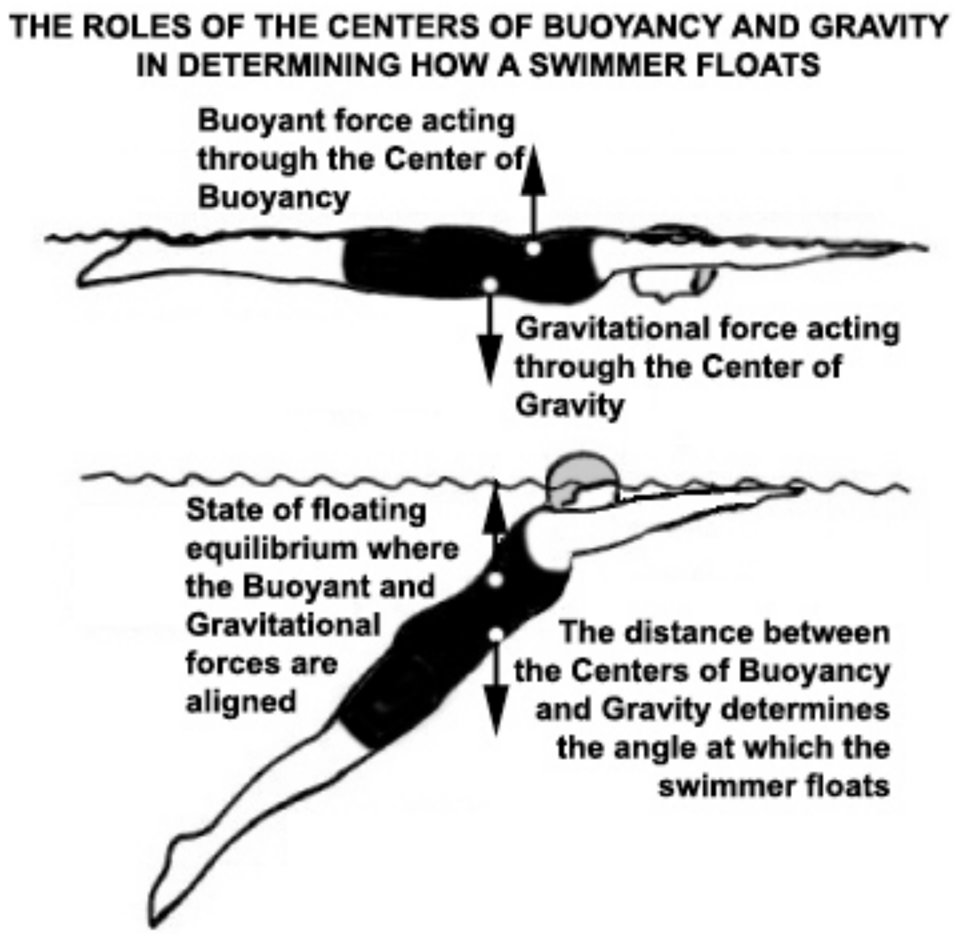

center of mass
fixed point on dancer's body


1.3 ft
2 ft

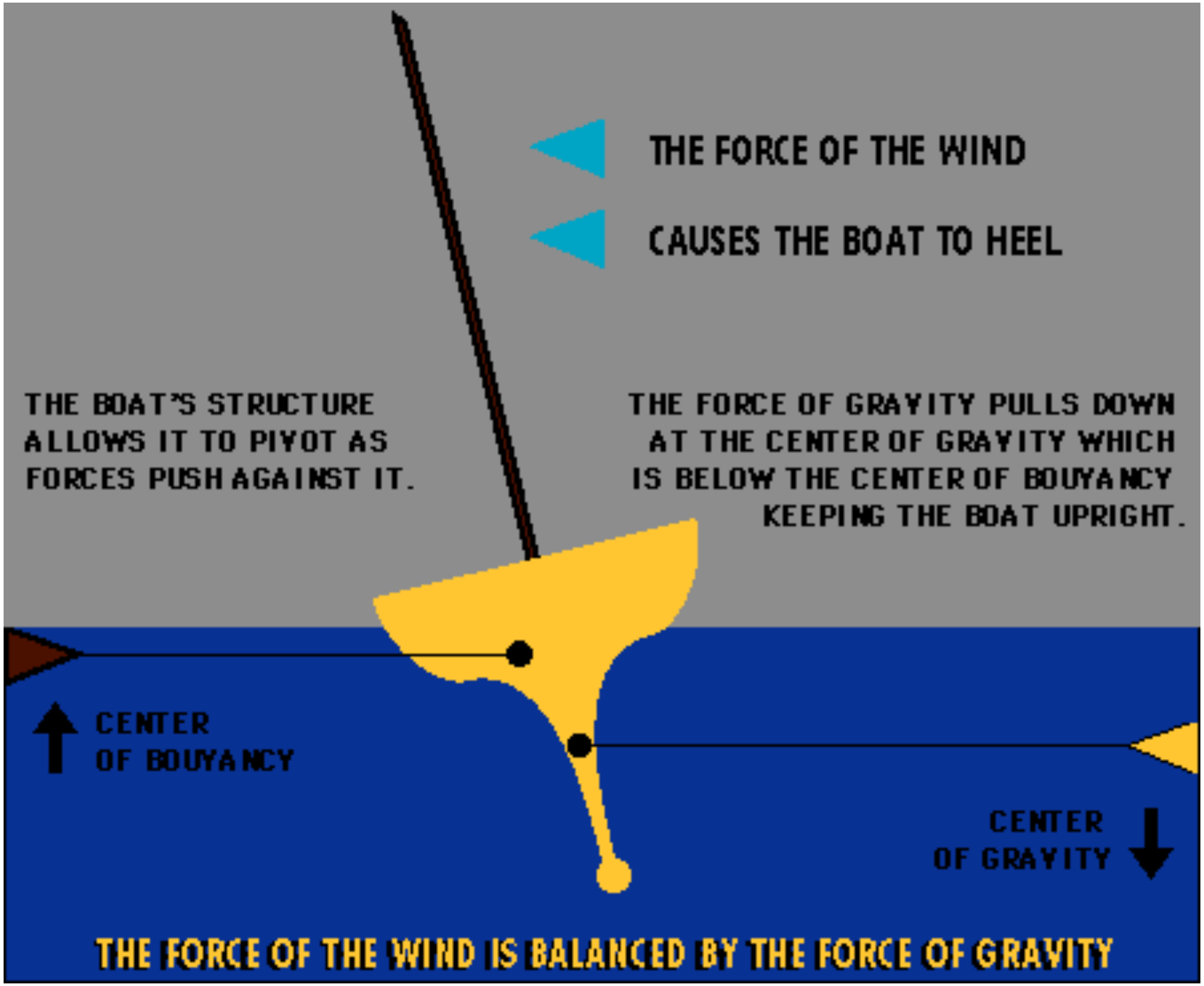

THREDBO
RAV4
ArlsPHOTO.com
by Adam Smith


1
2
3
4
5

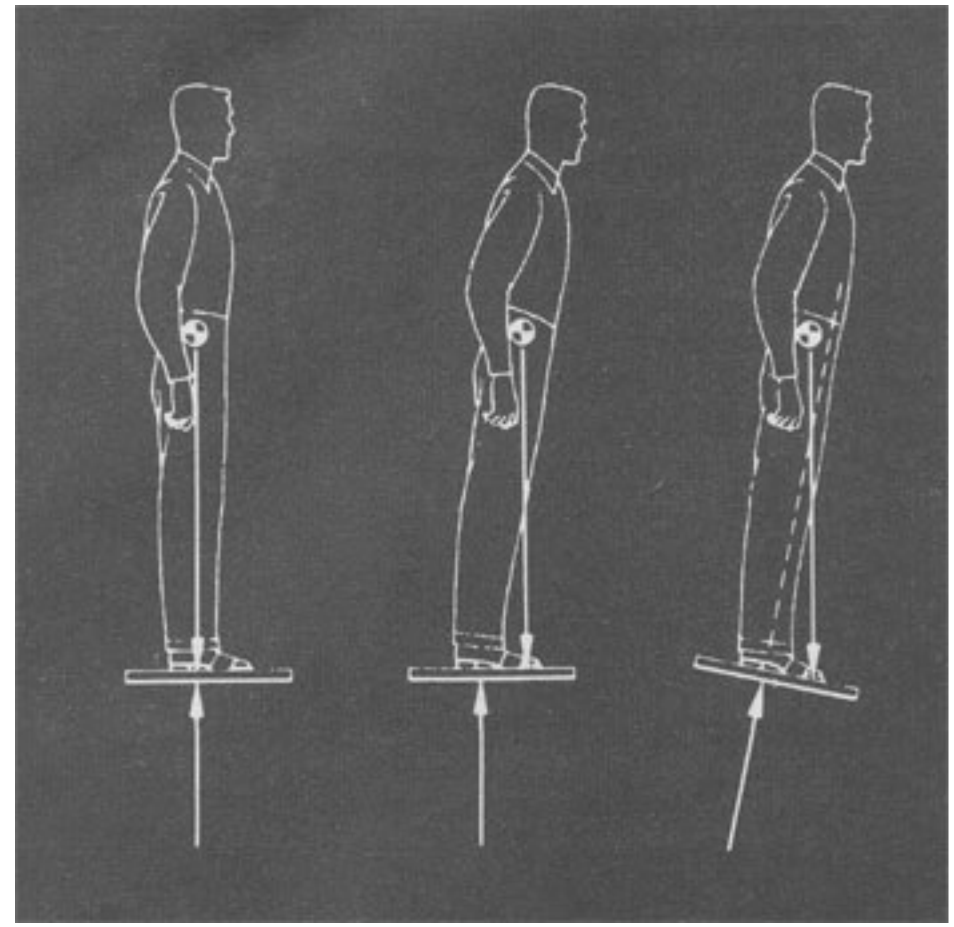
# Fingertip one-hand front lever




The center of buoyancy relates to the body's volume while the center of gravity relates to the body's mass. Since these two factors normally are different, they are usually sited in different areas of the body. The distance between the centers of gravity and buoyancy usually is greater for males than females.


THE FORCE OF THE WIND
CAUSES THE BOAT TO HEEL
THE BOAT'S STRUCTURE
ALLOWS IT TO PIVOT AS
FORCES PUSH AGAINST IT.
THE FORCE OF GRAVITY PULLS DOWN
AT THE CENTER OF GRAVITY WHICH
IS BELOW THE CENTER OF BOUYANCY
KEEPING THE BOAT UPRIGHT.
CENTER
OF BOUYANCY
CENTER
OF GRAVITY
THE FORCE OF THE WIND IS BALANCED BY THE FORCE OF GRAVITY

# Segway



# Segway measures center of gravity 100 times a second

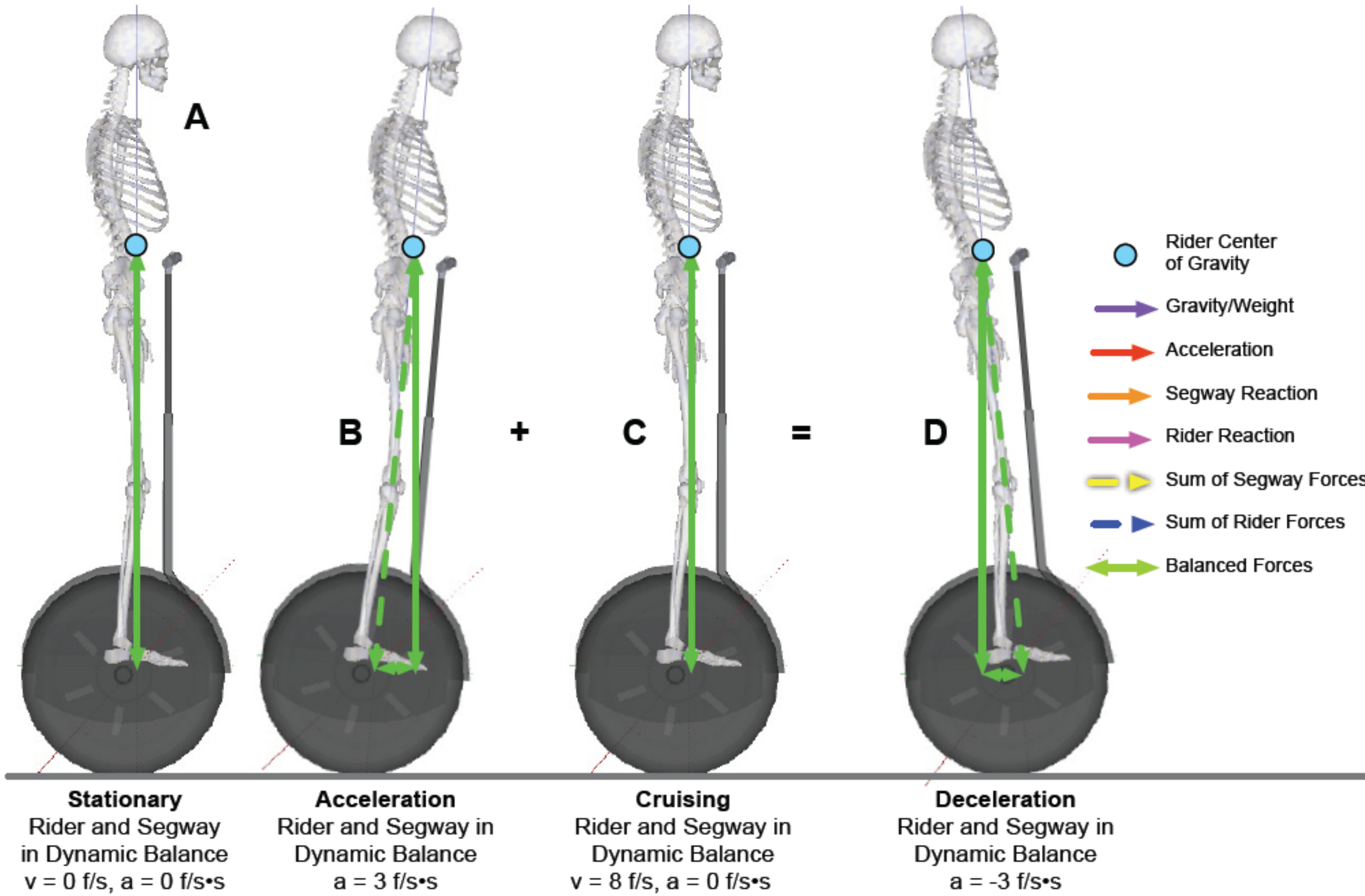
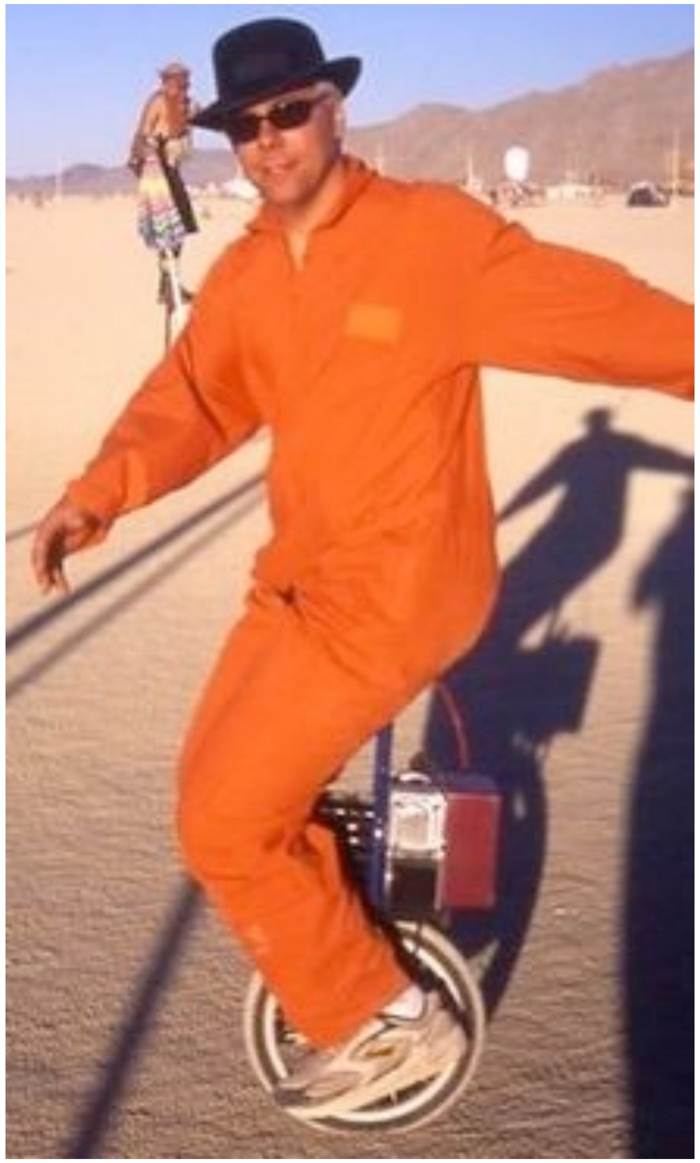



**Figure 4: Segway Balances the Forces on the Rider in All Phases of Riding**

# The Electric Unicycle



### Components

All together the components, in single unit retail quantities, cost about $1500. They are:

- A microcontroller board from BDMicro featuring the Atmel AVR Mega 128. $125.
- A gyroscope and acceleromoter by Rotomotion. $149.
- The OSMC motor controller by Robot Power. $199.
- 40 NIMH cells, made into nice packs by Robot Marketplace. $218.
- A Magmotor S28-150. $299
- The Whyachi TWM3M gearbox. $345.
- A 16-inch bicycle rim with spokes. $35 from your local bike shop. I use a 100 psi tire, which makes turning slightly easier.
- A custom-machined hub.
- A GT2 5 mm pitch belt, and 28 and 72-tooth pulleys. $21, $26 and $14.
- Some 1" diameter tubing, TIG-welded together. $40
- A guard for the upper pulley, machined from black Acetal plastic.
- Some spacer bushings to center the wheel.
- A combination dead man's switch and key. $12.
- A unicycle seat. $24.

The component I would most like to replace is the Whyachi gearbox. It makes a very loud gear whirring sound, which is fine for battlebots but undermines the graceful gliding look.

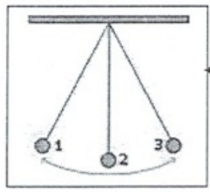
### Downloads

You can download the complete software here. The mechanical fabrication drawings are available in Postscript (use the Ghostscript viewer) and as an eDrawing (use the eDrawing viewer.)

http://tlb.org/eunicycle.html

# Experiment 2

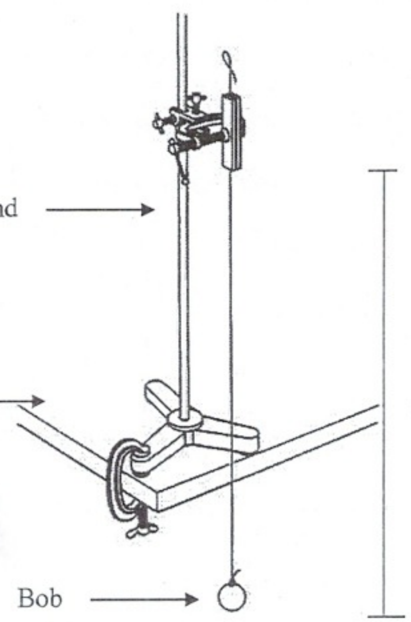
The study of Physics leads to the discovery that many different types of system have a natural oscillation. (E.g. swingy systems, springy systems, bouncy systems, wavy systems, musical systems and electrical systems.) The most elementary of these is the simple pendulum.
In this experiment you are going to investigate how changing the length and mass of a simple pendulum affects its period of oscillation i.e. the time taken for 1 swing.




One oscillation is the movement of the bob from 1 through 2 to 3 and then back to 1.

The apparatus is set up as shown in the diagram below with the pendulum bob having a mass, (M), of 10g.
Set the value of (L) (length of pendulum) to the 70 cm cotton reel.
All your observations and answers should be recorded on the back of this sheet.

Diagram of a pendulum




1. Pull the bob about 5cm to one side and then release it. Measure the time ($t_1$) for 10 oscillations and record this in Table 1.
2. Without changing the length or the mass of the pendulum, obtain a further value ($t_2$) for 10 oscillations and record this in Table 1.
3. Calculate and record the average time ($t_{average}$) for 10 oscillations, and hence calculate the period of 1 oscillation (T).
4. Change the value of (L) to the 60 cm cotton reel and repeat steps 1 to 3.
5. Change the value of (L) to the 50 cm cotton reel and repeat steps 1 to 3.

| Length (L) (cm) | Time 1 ($t_1$) (s) | Time 2 ($t_2$) (s) | Average Time ($t_{average}$) (s) | 1 Oscillation (T) (s) |
|---|---|---|---|---|
| 70 | | | | |
| 60 | | | | |
| 50 | | | | |

Table 1: Time taken for varying lengths of a pendulum

Describe how (T) (time for one oscillation) changes as (L) (length of the pendulum) increases.

________________________________________

________________________________________

You are now going to keep (L) at 50 cm and change the value of the mass (M).

6. Copy the results from the last horizontal row of Table 1 into the first horizontal row of Table 2.
7. Increase the value of (M) to the 30g cotton reel and repeat steps 1 to 3, recording these values in Table 2.
8. Increase the value of (M) to the 50g cotton reel and repeat steps 1 to 3.

| Mass (M) (g) | Time 1 ($t_1$) (s) | Time 2 ($t_2$) (s) | Average Time ($t_{average}$) (s) | 1 Oscillation (T) (s) |
|---|---|---|---|---|
| 10 | | | | |
| 30 | | | | |
| 50 | | | | |

Table 2: Time taken for varying masses of the bob

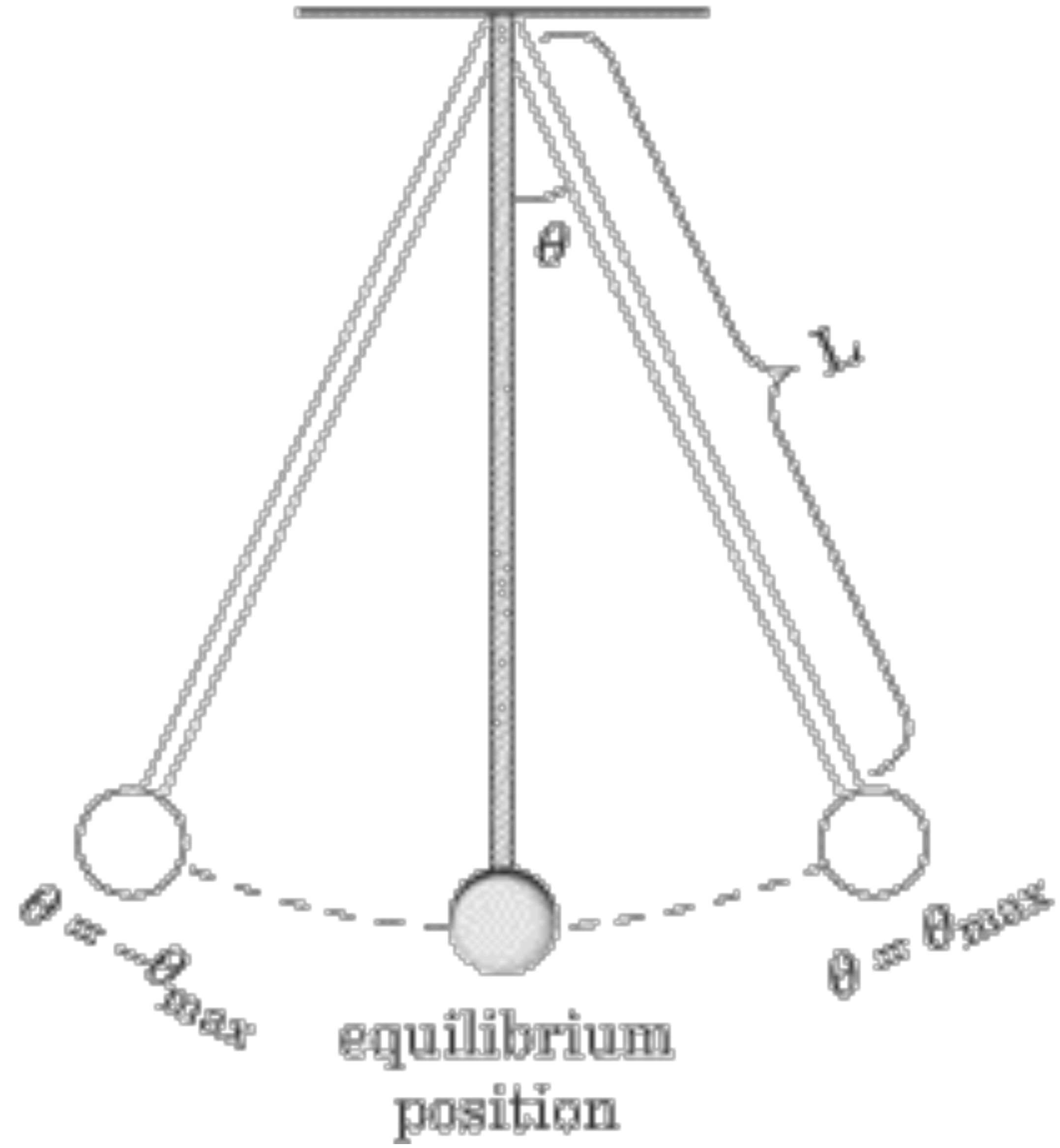
Describe any effect of a change in (M) (mass of the bob) on the value of (T) (time for one oscillation).

________________________________________

________________________________________

# Apollo 15 David Scott

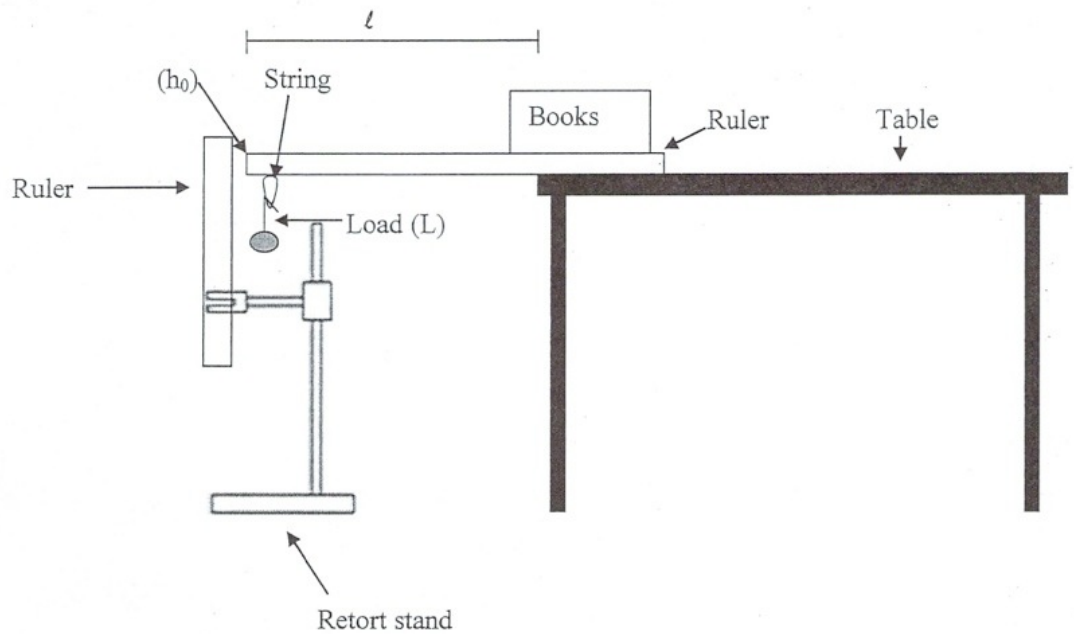
$$T = 2\pi\sqrt{\frac{L}{g}}$$



# Experiment 3

When a force is applied to an object so that its shape is changed, the force is known as **stress**, and the change of shape is known as **strain**. Elasticity is the property of a substance to return to its original shape when the **stress** is removed.
Most solid materials have elastic properties, even if very slight, and the relationship between **stress** and **strain** is often linear (i.e. graph is a straight line) as long as the **stress** does not exceed a size that is known as the elastic limit of the material.

In this experiment you are to investigate the bending of a wooden beam




The apparatus is set up as shown in the diagram.
Use the back of this sheet to write down your readings and draw a graph.

1. Read and record the length, ($l$), of the wooden beam overhanging the table.
2. Read and record the position, ($h_0$), of the top edge of the beam against the metre ruler when there is no load attached.
3. Hang a load, (L), of 100g from the loop of string and read the position, (h), of the top edge of the beam in its deflected position. (NB: the mass pieces provided are 50g each)
4. Record the values of (L) and (h) in the table provided, and calculate the value of the deflection (d)**$d = (h - h_0)$**, which corresponds to this load.
5. Repeat for loads of 200g, 300g, 400g and 500g.
6. On the grid provided, plot a graph of (d) against (L), and draw the line of best fit.
7. What would the graph look like if the experiment was repeated with a smaller value of ($l$) (the length of the beam)? **Note: do not carry out this experiment.**

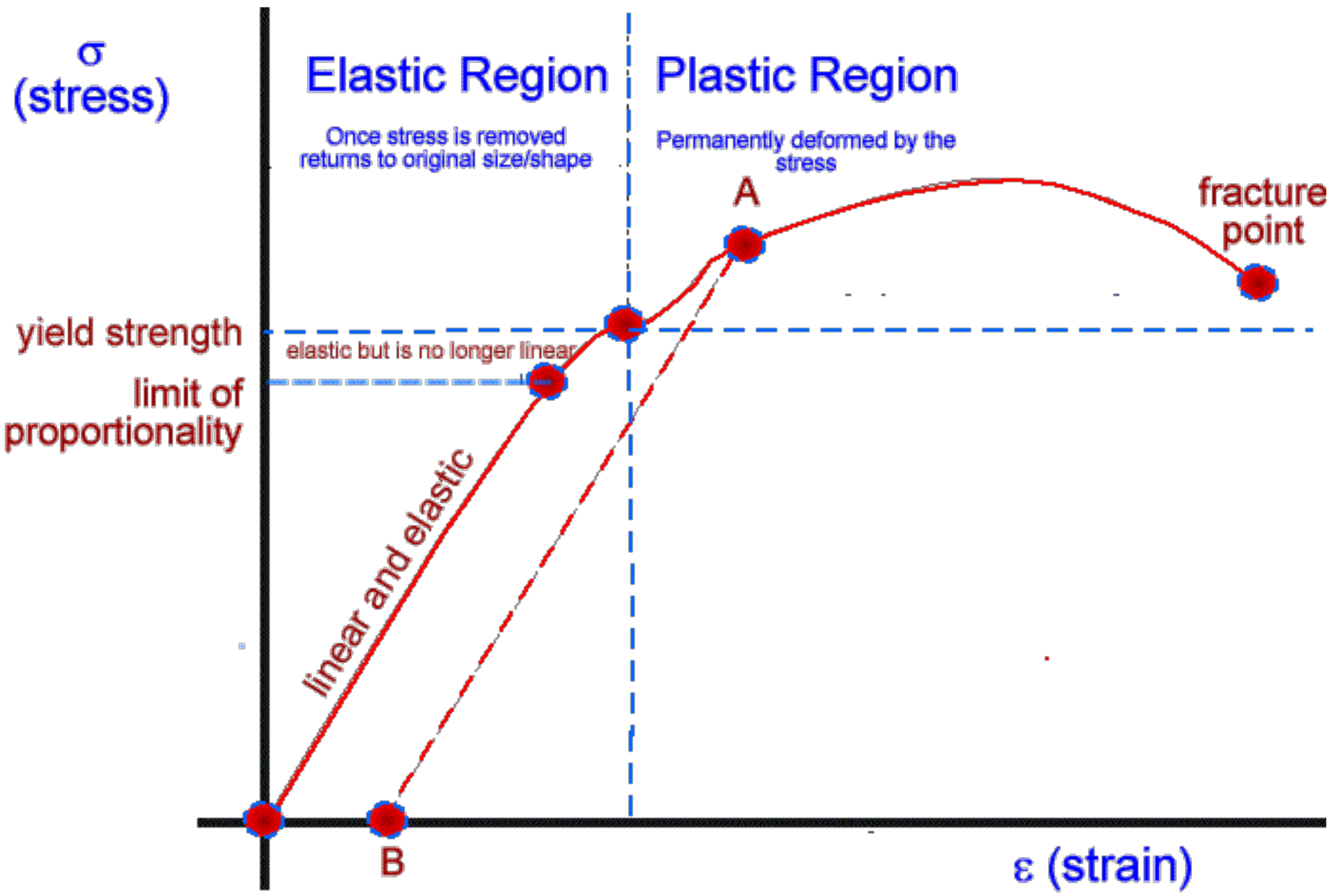
________________________________________

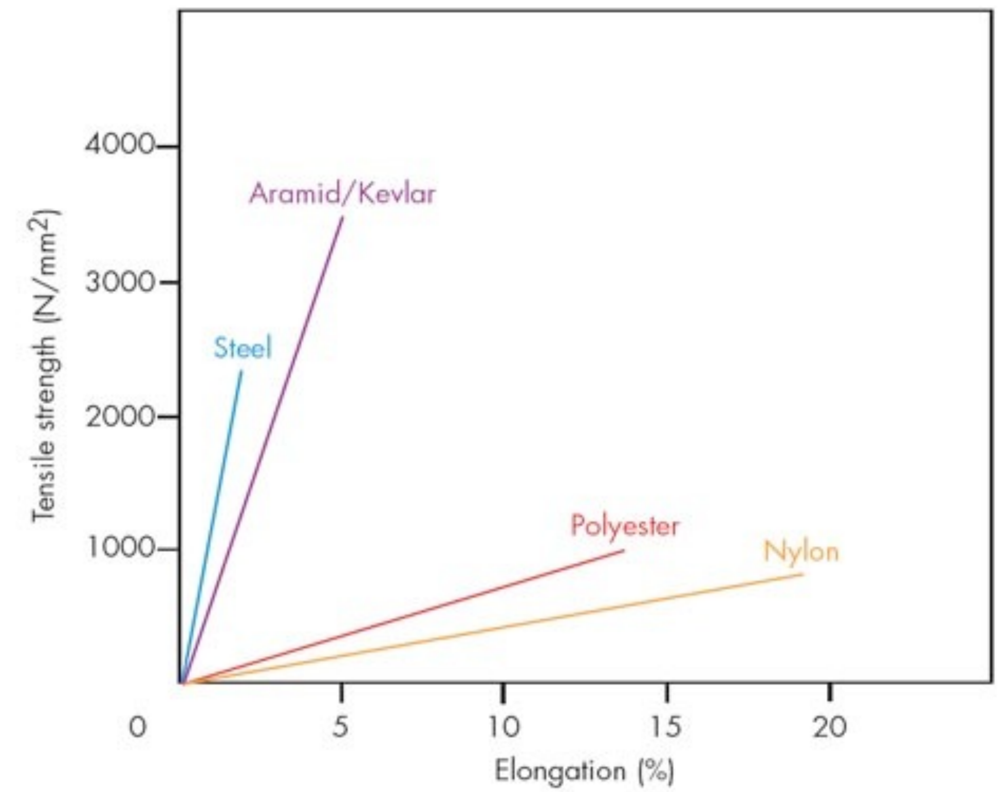
________________________________________

$l$ = ________________________

| Load (g) | Initial height of beam ($h_o$) (cm) | Height of beam (h) (cm) | Deflection $d = (h - h_0)$ (cm) |
|---|---|---|---|
| 0 | | | |
| 100 | | | |
| 200 | | | |
| 300 | | | |
| 400 | | | |
| 500 | | | |

Table showing the deflection of a wooden beam


σ
(stress)
Elastic Region
Once stress is removed
returns to original size/shape
Plastic Region
Permanently deformed by the
stress
A
fracture
point
yield strength
elastic but is no longer linear
limit of
proportionality
linear and elastic
B
ε (strain)


4000
3000
2000
1000
Tensile strength (N/mm2)
Aramid/Kevlar
Steel
Polyester
Nylon
0
5
10
15
20
Elongation (%)

# Stress/Strain for Pine