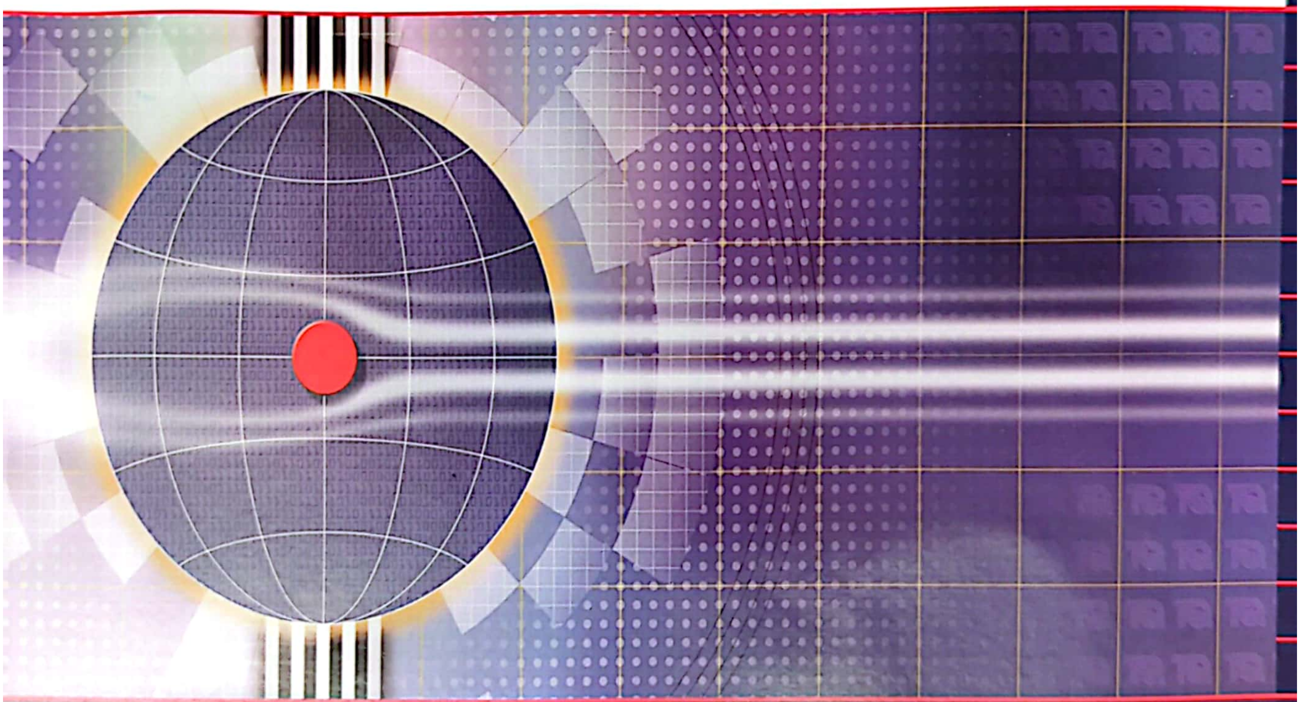
TecQuipment

H314a

Surface Tension Balance

User Guide



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SECTION 1.0 INTRODUCTION

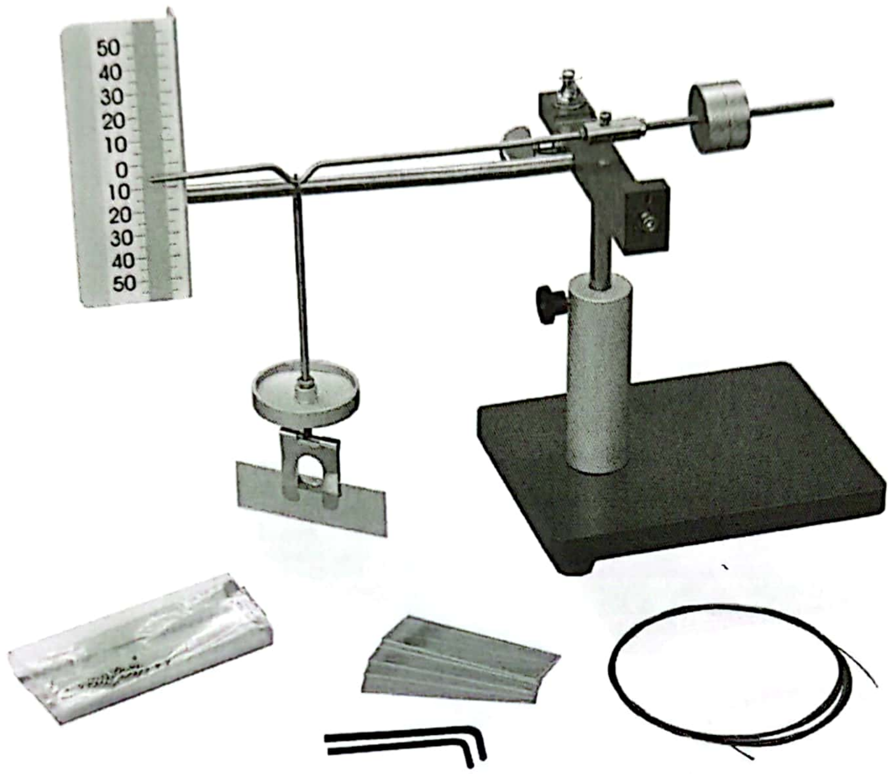

Figure 1 The Surface Tension Balance (H314a)

The balance helps to find the surface tension of any clear liquid or soap solution. It uses the 'Direct Pull' method - based on the design of the physicist Dr GFC Searle, F.R.S. It works in a similar way to a simple weighing scale. However, this balance uses the torsional spring properties of a wire as a restoring force to keep the balance level.

The surface tension balance works as an ancillary to TecQuipment's Hydrostatics and Properties of Fluids (H314). The H314 includes at least one beaker of suitable size for use with the surface tension balance.

SECTION 2.0 DESCRIPTION

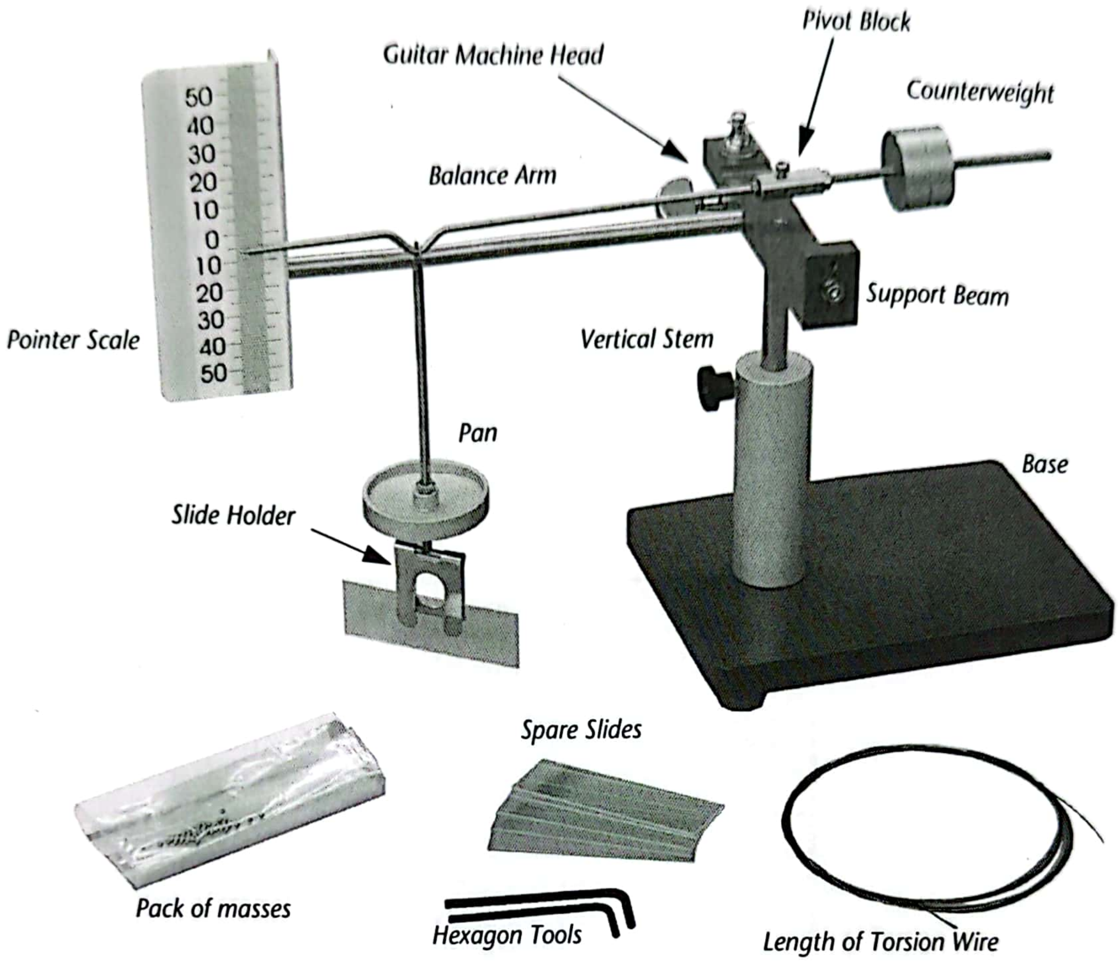

Figure 2 Parts of the H314a

The balance has a heavy base to keep it stable. The base holds a vertical mounting stem, which holds a support beam. The support beam has a standard machine screw at one end, and a guitar wire machine head at the other. The torsion wire fits between the machine screw and guitar machine head. It passes through the pivot block of the balance arm. The guitar machine head allows you to apply the correct tension to the torsion wire.

At one end of the balance arm, a counterweight helps to zero the balance arm before each test. At the other end of the balance arm, its pointer moves against a scale to show deflection. The balance arm also holds a balance pan and slide holder. The slide holder grips a glass slide.

You use the counterweight to set the pointer to zero, then lift your liquid up to immerse the edge of the glass slide. You then carefully lower the liquid while watching the pointer against the scale. The surface tension keeps the glass slide connected to the liquid. At some point, the surface tension becomes too weak to hold the slide and the connection breaks. The pointer returns to its original position. This breaking point is the 'critical reading' on the scale. Glass slides work well with this equipment, as they have a smooth surface and you can clean them easily.

You then add small masses to the balance pan until the pointer returns to the critical reading. The value of the masses and the submerged area of the slide allows you to find the surface tension of the liquid. Note that TecQuipment supply a small pack of precision-machined ball-bearings as masses, but you could use your own equivalent masses.

The sensitivity of the balance depends on the spring constant of the torsion wire. A thinner wire would give more sensitivity but less durability, a thicker wire would give more durability but less sensitivity. TecQuipment has chosen the best wire for durability and sensitivity. In case you damage the wire, TecQuipment include spare wire to replace it.

SECTION 3.0 TECHNICAL DETAILS

Item	Details
Dimensions and weight (assembled)	350 mm long x 150 mm wide x 270 mm high and 2.8 kg
Pointer Deflection	Approximately 10 mm for 1 g mass
Length of torsion wire	1 m 24 SWG Piano wire
Masses	50 off 2 mm diameter stainless steel bearings Nominal mass 0.033 g each
Density of stainless steel	7870 kg.m^{-3}
Glass Slides	5 off Nominal dimensions: 76 mm long (l) x 1 mm thick (d) Note: For best results, measure your glass slides accurately before use.
Tools included	2 x hexagon tools

Table 1 Technical Details

Liquid	Surface Tension (N/m)
Clean Water at 10°C	0.0742
Clean Water at 20°C	0.0728
Clean Water at 30°C	0.0712
Clean Water at 40°C	0.0696
Soapy Water at 20°C	0.0250 to 0.045

Table 2 Typical Values of Surface Tension

SECTION 4.0 ASSEMBLY AND SETTING UP

4.1 Assembly

Using Figures 1 and 2 as a guide, assemble the main parts of the balance.

4.2 Setting the Torsion Wire

WARNING ***Wear eye protection and take care when handling and cutting the wire, it may leave sharp edges.***

1) See Figure 3. Thread the torsion wire around the guitar machine head, through the pivot block and through the small hole opposite to the guitar machine head.
   Wrap the wire at least once around the machine head and once around the machine screw at the opposite side. Use the hexagon tool supplied to tighten the machine screw.

2) Use suitable wire cutters (not supplied) to trim off any excess wire.

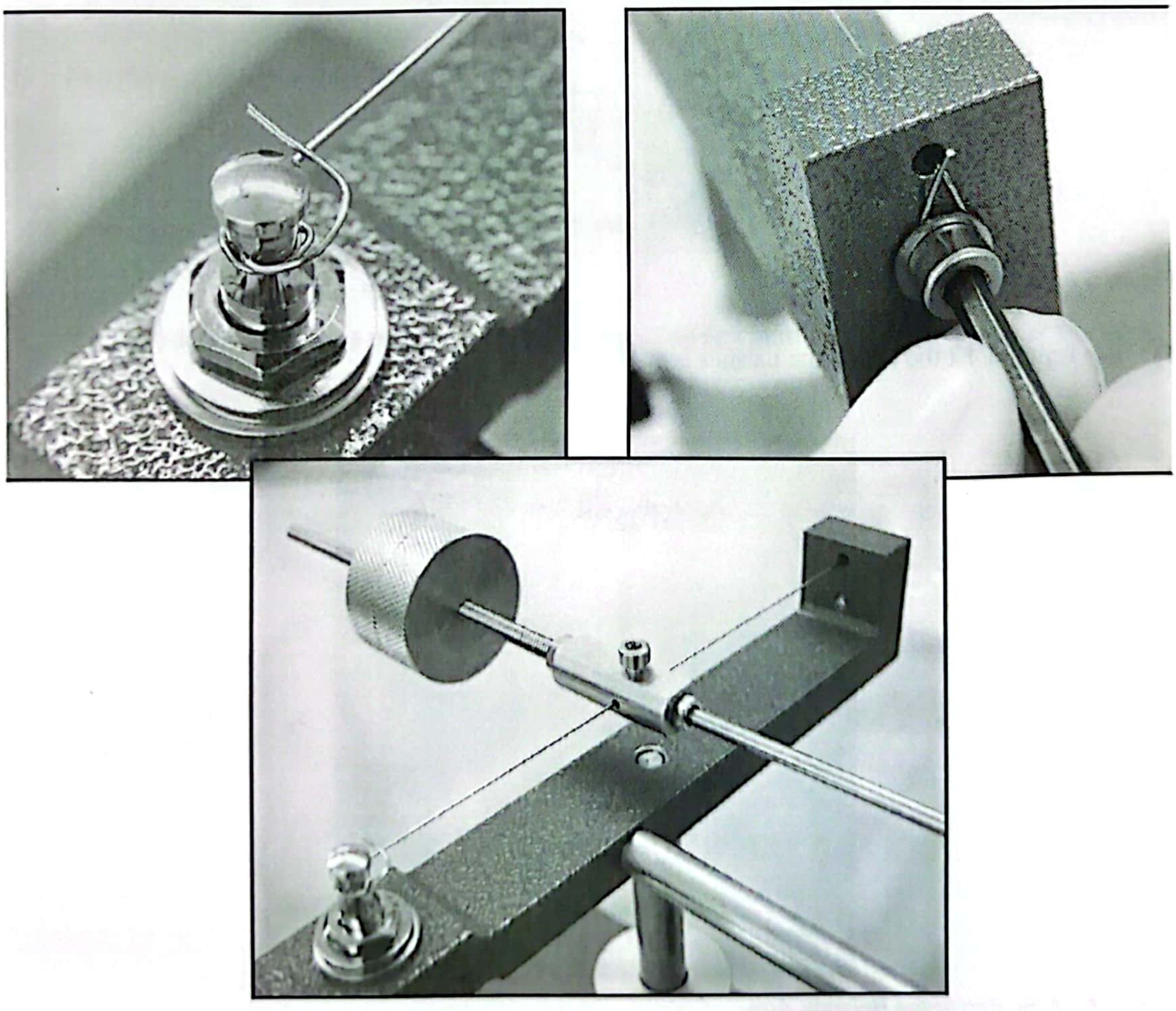

Figure 3 Thread the Torsion Wire through its Supports and the Pivot Block

3) See Figure 4. Tighten the guitar machine head so that the wire is tight.

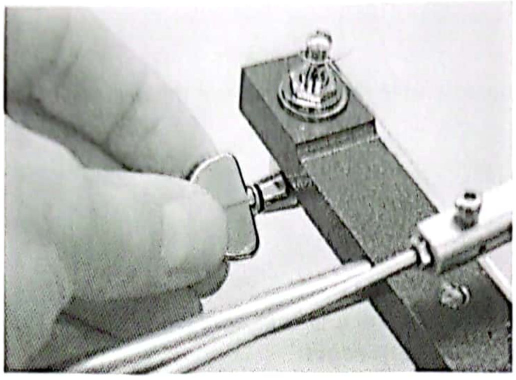

Figure 4 Tighten the Guitar Machine Head

4) See Figure 5. Adjust the counterweight so that it is around the middle of its adjustment.

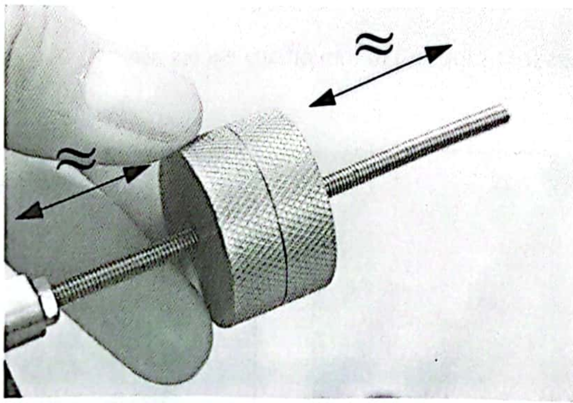

Figure 5 Adjust the Counterweight

5) See Figure 6. Fit the Pan to the balance arm.

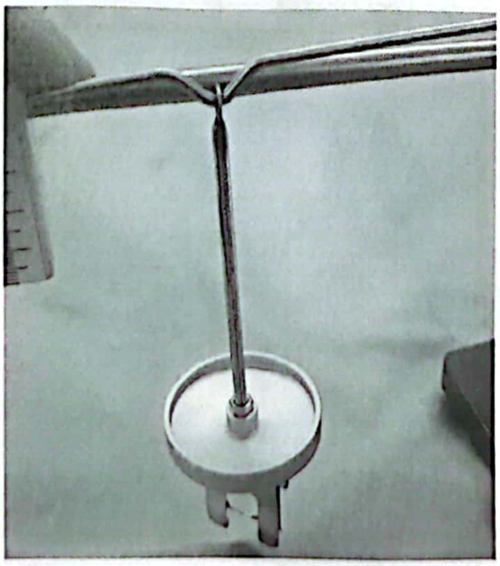

Figure 6 Fit the Pan to the Balance Arm

6) See Figure 7. Use the hexagon tool supplied to clamp the torsion wire in the pivot block when the balance arm pointer is near to zero (+/- 4) on the scale. Tighten the pivot block fixing just enough to clamp the wire. Too tight and you may break the wire.

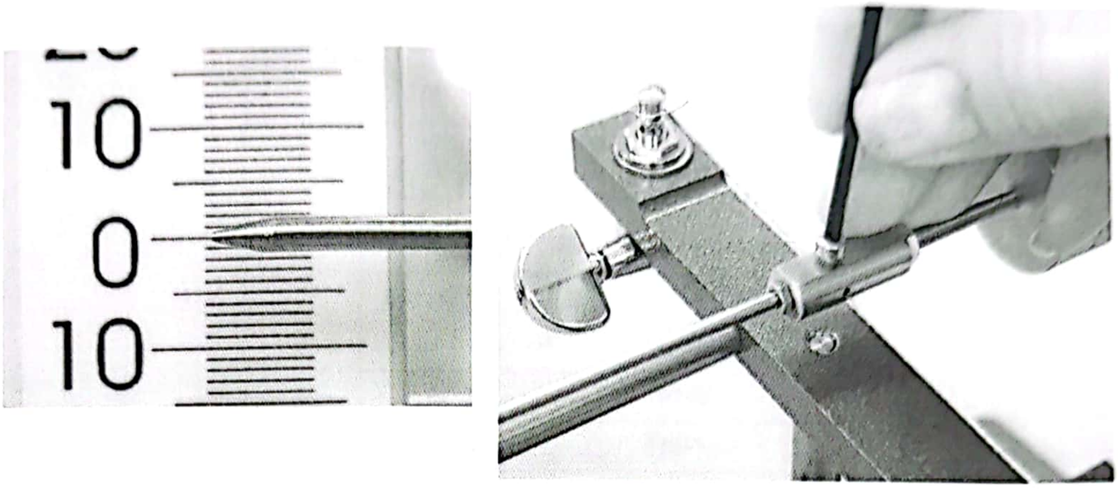

Figure 7 Clamp the Torsion Wire when the Pointer is Near to Zero

4.3 Positioning the Balance

1) Fit a clean glass slide to the holder.

WARNING ***Take care when using the slides. They are made of glass.***

2) Put the balance near to the edge of a flat, level, table. The pan must hang over the edge of the table.

3) Make sure that the base is level.

SECTION 5.0 THEORY

5.1 Notation

Symbol	Units	Details
γ	N/m	Surface Tension.
l	m	Length of Glass Slide.
d	m	Thickness of the Glass Slide.
m	kg	The mass (load) in the pan.
g	9.81 m.s^{-2}	Acceleration due to gravity.
V	m^3	Volume.
ρ	kg.m^{-3}	Density.
r	m	Radius.

Table 3 Notation

Note: A mass in kg gives surface tension in N/m

5.2 Surface Tension

From the Concise Oxford English Dictionary:

Surface tension is the tension of the surface film of a liquid, which tends to minimize surface area.

It is an elastic property that exists at the surface of liquids (at the boundary between the liquid and air). It allows insects to float and walk on the surface of water.

Temperature affects the surface tension of water such that a higher water temperature reduces its surface tension. Adding soapy chemicals to water also reduces its surface tension.

5.3 Mass of the Small Spheres

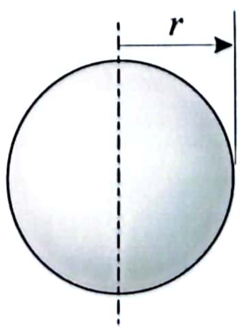

Figure 8 Volume of a Sphere

To find the mass of the small spherical masses supplied with the balance, you may weigh them using an accurate weighing scale, or calculate their mass using their volume and density. They are precision-machined ball-bearings, so they have very accurate dimensions.

The volume of a sphere is:

$$V = \frac{4}{3}\pi r^3 \tag{1}$$

So, for a 2 mm (0.002 m) diameter sphere, r = 0.001 m, and

$$V = 4/3\ \pi\ 0.001^3$$

$$= 4.18879 \times 10^{-9}\ \mathrm{m}^3$$

$$\text{Mass } m = \text{Density } \rho \times \text{Volume } V \tag{2}$$

So, where $\rho = 7870\ \mathrm{kg.m^{-3}}$,

$$m = 7870 \times 4.18879 \times 10^{-9} = 0.000032966\ \mathrm{kg}\ (0.033\ \mathrm{g})$$

5.4 Calculating Surface Tension Using Glass Slides

The area of the edge of the submerged glass slide and the weight equivalent to the critical reading gives the surface tension of the liquid:

$$\gamma = \frac{mg}{2(l+d)} \tag{3}$$

$$\text{Downward pull (critical weight)} = mg = 2\gamma(l+d) \tag{4}$$

SECTION 6.0 TEST PROCEDURE

1) Create a blank table similar to Table 4.

2) Into your table, record the dimensions of the glass slide and the ambient temperature.

Liquid: Temperature:	
Glass Slide Length l (m)	
Glass Slide thickness d (m)	
$2(l+d)$	
Critical Reading	
Mass m (kg)	
Critical Weight mg (N)	
Surface Tension γ (N/m)	

Table 4 Blank Results Table

3) Assemble the apparatus as shown in "Assembly And Setting Up" on page 7.

4) Pour the test liquid into a clean container. Note that if you use soapy water, try to remove any surface bubbles, so the slide meets a clear, flat surface.

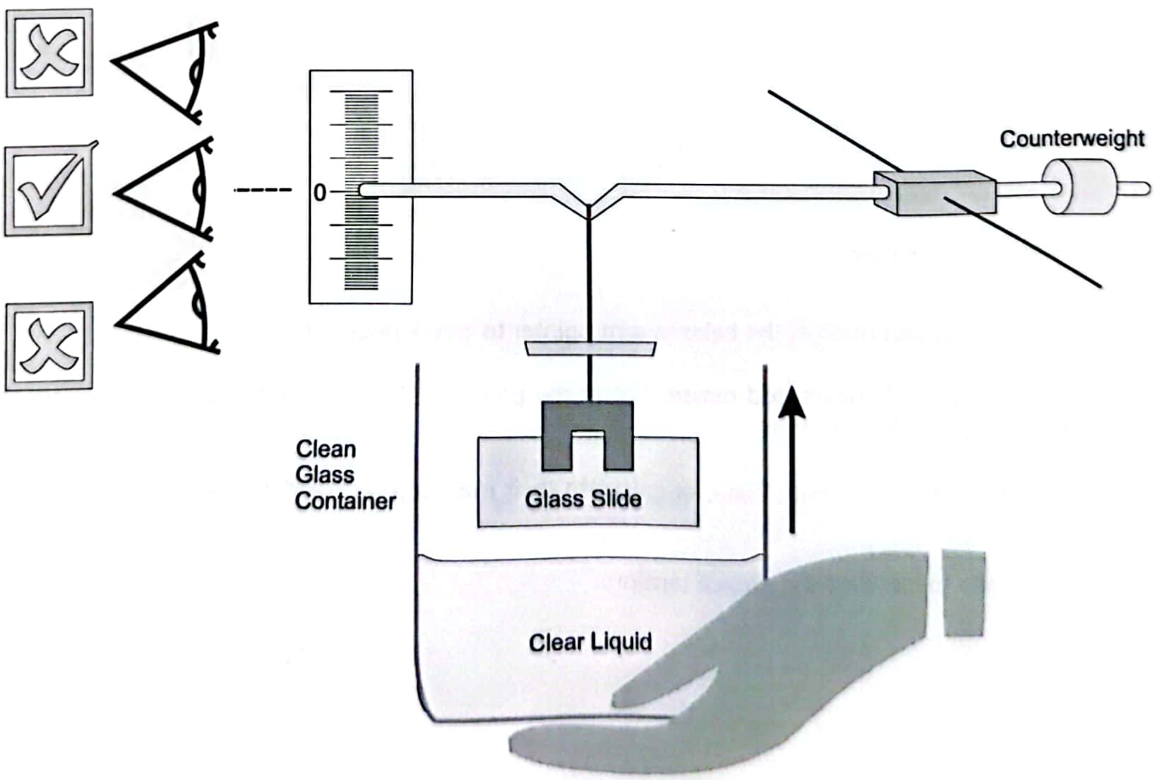

Figure 9 Lift the Container

5) Use the counterweight to set the balance arm pointer to zero on the scale. Take care to look directly at the pointer and scale, not above or below, or you will make an error in the reading due to 'parallax error'.

6) As shown in Figure 9, raise the container until the edge of the glass slide is submerged in the test liquid.

7) As shown in Figure 10, slowly lower the container while watching the pointer against the scale.

8) When the glass slide breaks away from the liquid, record the reading on the scale. This is the 'critical reading'.

9) Repeat at least three times to make sure your reading is accurate.

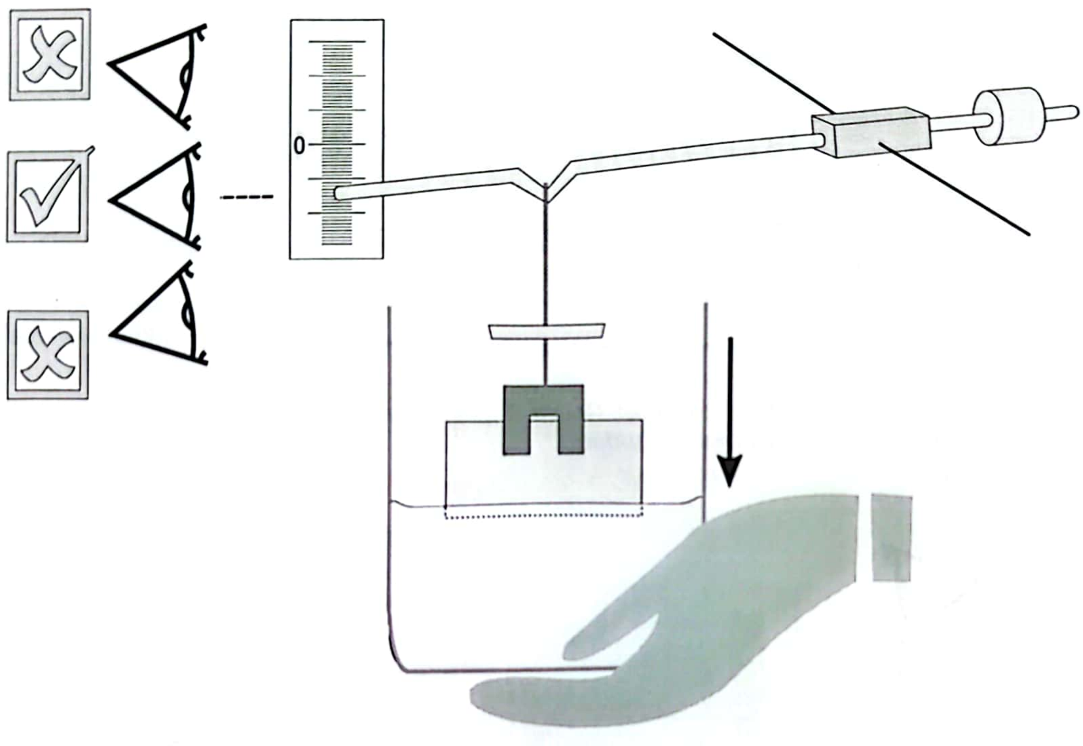

Figure 10 Lower the Container

10) Dry the glass slide and readjust the balance arm pointer to zero if necessary.

11) As shown in Figure 11, slowly add masses (m) to the pan until the balance arm pointer indicates the 'critical reading' you found earlier.

12) Take out the masses and weigh them, or calculate their mass using their dimensions as shown in the thoery.

13) Use your results to calculate the surface tension.

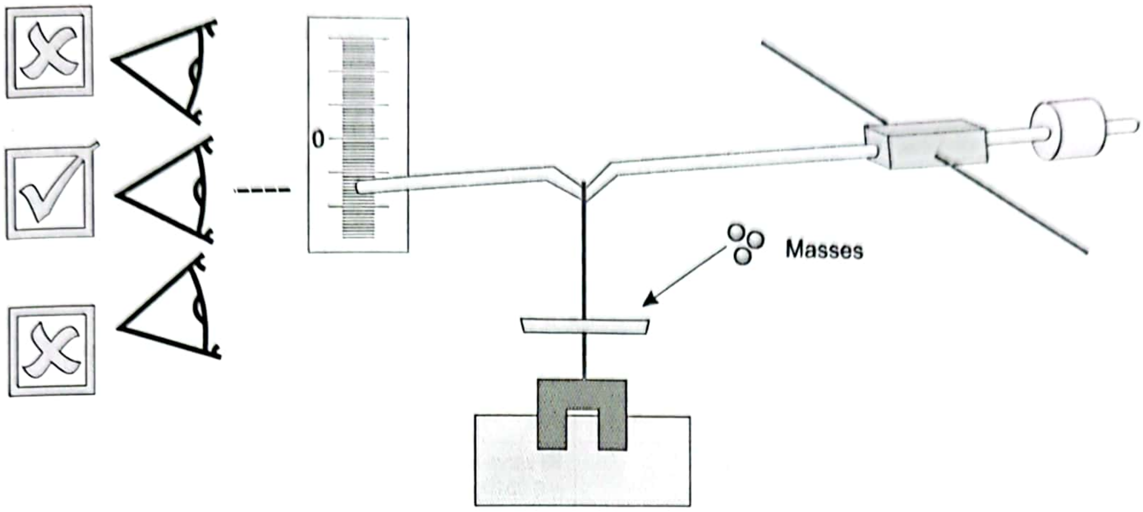

Figure 11 Add Masses to the Pan

6.1 After Use

When you have finished your experiments, use the guitar machine head to reduce the tension in the wire. This reduces the chances of accidentally stretching or damaging the wire.

Clean the glass slide using soapy water or glass cleaner, then rinse with distilled water and use a clean cloth to dry it. Store the slides safely.

Carefully store the balance in a dry, cool place until needed again.

6.2 Typical Results

These are typical results only. Your results may be slightly different, determined by temperature and the qualities of your liquid.

Liquid: Clean Water Temperature: 20°C	
Glass Slide Length l (m)	76 mm (0.076 m)
Glass Slide thickness d (m)	1 mm (0.001 m)
$2(l + d)$	2 (0.076 + 0.001) = 0.154
Critical Reading	10
Mass m (kg)	33 spheres x 0.033 g = 0.001089 kg
Critical Weight mg (N)	0.001089 x 9.81 = 0.010683
Surface Tension γ (N/m)	0.010683/0.154 = 0.06937

Table 5 Typical Results

Liquid: Soapy Water Temperature: 20°C	
Glass Slide Length l (m)	76 mm (0.076 m)
Glass Slide thickness d (m)	1 mm (0.001 m)
$2(l + d)$	2 (0.076 + 0.001) = 0.154
Critical Reading	6
Mass m (kg)	16 spheres x 0.033 g = 0.0003237 kg
Critical Weight mg (N)	0.0003237 x 9.81 = 0.0031755
Surface Tension γ (N/m)	0.0031755/0.154 = 0.0206

Table 6 Typical Results

These typical results show that the balance can give reasonably accurate results when set up and used correctly. They also show that adding a soap solution to water will greatly reduce its surface tension.

SECTION 7.0 MAINTENANCE, SPARE PARTS AND CUSTOMER CARE

7.1 Maintenance

TecQuipment supply a length of spare torsion wire with the balance. To replace the wire, use a pair of strong wire cutters (not supplied) and cut off a suitable length. Fit the wire as shown in "Assembly And Setting Up" on page 7.

WARNING **Wear eye protection and take care when handling and cutting the wire, it may leave sharp edges.**

7.2 Spare Parts

Check the Packing Contents List to see what spare parts we send with the apparatus.

If you need technical help or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

When you ask for spares, please tell us:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if you know it)
- The serial number
- The year it was bought (if you know it)

Please give us as much detail as possible about the parts you need and check the details carefully before you contact us.

If the product is out of warranty, TecQuipment will let you know the price of the spare parts.

7.3 Customer Care

We hope you like our products and manuals. If you have any questions, please contact our Customer Care department:

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