Shika Express - Physics
Version 1.0 TZ

Hands-On Activities Companion Guide

Tanzania

Teacher's Guide

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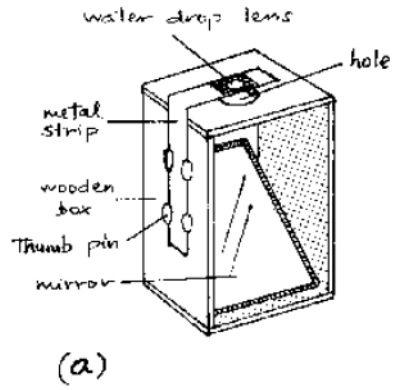
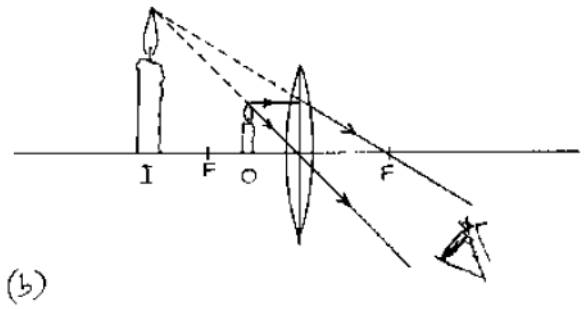
3.1.1 Simple Microscope





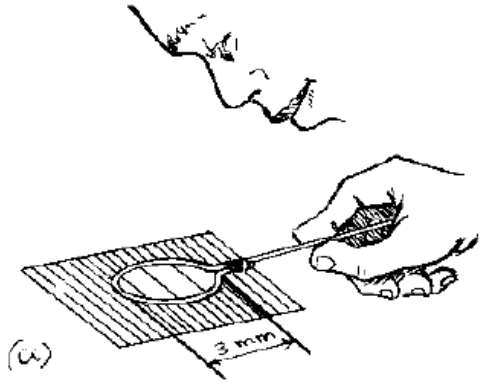
Materials: Mirror, thumb pins, wooden box, metal strip, knife

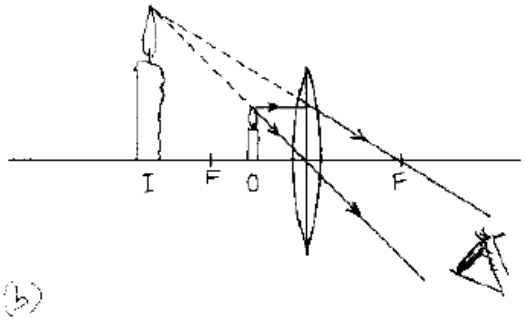
Setup: Construct the simple microscope according to the figure above.

Procedure: Adjust the mirror so that sun rays are reflected to the hole below the lens. Place a transparent object (e.g. wing of a fly) on the hole and adjust the metal strip so that the water drop lens has less distance from the object than its focal length, as shown in the ray diagram.

Theory: The lens acts as a magnifying glass. When the object distance decreases, the magnification increases

3.1.2 Magnification





Materials: Paper clip, pen, water bottle, water

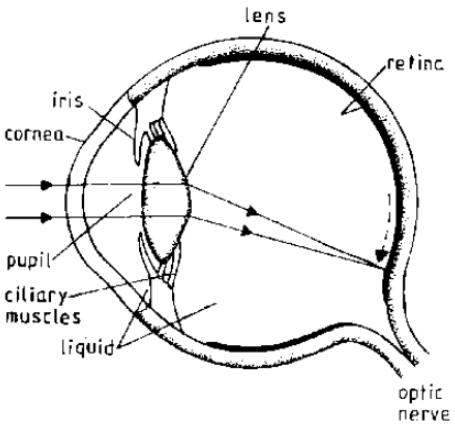
Setup: Make a loop using paper clip wire and wind around a pen to construct a magnifying glass.

Procedure: Dip the loop in water and use the magnifying glass to observe small objects or letters in a book. Alternatively, fill a water bottle and hold it over the object/letters.

Theory: The water drop and water bottle act as convex lenses. According to the ray diagram shown, the image is larger than the object. The image is also virtual and the object distance is less than the focal length.

Applications: Magnifying glass, microscopes, telescopes, etc.

3.1.3 Human Eye



Procedure: Draw a display chart of the above figure on a manila sheet and post in the classroom.

Theory: The eye contains a convex lens which focuses light on a sensitive membrane called the retina. Unlike a camera, the eye lens changes its curvature and hence focal length to focus light from objects at various distances. The focal length varies according to object distance, while the image distance is kept constant and is roughly equal to the diameter of the eye.

Physics Activities for Form IV

Local Materials List

In order to gain a thorough understanding of science, students must be able to make a connection between classroom learning and the outside world. The following is a list of locally available materials which may be used to substitute conventional materials and apparatus for various activities. These materials have the following advantages:

- They are readily available in the village or a nearby town;
- They are cheaper than conventional materials;
- They may safely substitute the conventional materials without fear of losing accuracy or understanding;
- They help students to draw a connection between science education and the world around them.

Imagination and innovativeness is encouraged on the part of the student and teacher to find other suitable local substitutions.

Throughout this book you will see materials that have been marked with an asterisk (*). These are items which may be made or purchased using locally available substitutes. The guide for using and making these local materials is found in this section.

Alligator Clips

Use: Connecting electrical components
Materials: Clothespins, aluminum foil, glue
Procedure: Glue aluminum foil around the clamping tips of a clothespin.

Balance

See the Form I activity on **??**.

Beakers

Use: To hold liquids, to heat liquids
Materials: Water bottles, jam jars, metal cans, knife/razor
Procedure: Take empty plastic bottles of different sizes. Cut them in half. The base can be used as a beaker. Jam jars made of glass or cut off metal cans may be used when heating.

Bunsen Burner

See .

Circuit Components

Use: Building simple circuits, Ohm's Law, amplifier, wave rectifiers
Materials: Broken radio, computer, stereo, other electrical devices
Procedure: Remove resistors, capacitors, transistors, diodes, motors, wires, transformers, inductors, rheostats, pulleys, gears, battery holders, switches, speakers and other components from the devices. Capacitors tend to state their capacitance in microFarads on their bodies.

Delivery Tube

Use: For the movement and collection of gases, capillary tubes, hydraulic press
Materials: Straws, pen tubes, IV tubing (giving sets) from a pharmacy, bicycle tubing, or pawpaw petioles

Drawing Board

Use: Reflection, refraction of light
Materials: Thick cardboard

Droppers

Use: To transfer small amounts of liquid
Materials: 2 mL syringes
Procedure: Take a syringe. Remove the needle to use as a dropper.

Eureka Can

Use: To measure volume of an irregular object, Archimedes' Principle, Law of Flotation
Materials: Plastic bottle, knife, Optional: super glue, straw, nail, candle
Procedure: Cut the top off of a 500 mL plastic bottle. Then cut a small strip at the top (1 cm wide by 3 cm long) and fold down to make a spout. Alternatively, heat a nail using a candle and poke a hole near the top of a cut off bottle. Super glue a straw so that it fits securely in the hole without leaking.

Funnel

Use: To guide liquid or powder into a small opening
Materials: Empty water bottles, knife
Procedure: Take an empty water bottle and remove the cap. Cut it in half. The upper part of the bottle can be used as a funnel.

Glass Blocks

Use: Refraction of light
Materials: 8 mm - 15 mm slabs of glass
Procedure: Have a craftsman make rectangular pieces of glass with beveled edges, so students do not cut themselves. Glass blocks from a lab supply company are generally 15 mm thick. 8 mm and 10 mm glass is relatively common in towns. 12 mm and thicker glass exists though is even more difficult to find. Stack several pieces of thinner glass together and turn them on their edge.

Heat Source

Use: Heating substances
Materials: Candles, kerosene stoves, charcoal burners, Motopoa (alcohol infused heavy oil), metal can, bottle caps, butane lighter
Procedure: Cut a metal can in half or use a bottle cap and add a small amount of Motopoa.

Iron Filings

Use: To map magnetic fields
Materials: Steel wool / Iron wool used for cleaning pots
Procedure: Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

Light Bulbs

Use: Electrical circuits, diodes
Materials: Broken phone chargers, flashlights, other electronic devices
Procedure: Look for LEDs from broken items at hardware stores, local technicians, or small shops.

Masses

Use: Calibrating and using beam balance and spring balance, Hooke's Law
Materials: Known masses, beam balance, empty bottles, plastic syringe, water, plastic bags, sand, stones, thread, paper, tape, pen
Procedure: Use a beam balance and known masses at a market or nearby school to measure exact masses of sand or stones. Use a marker pen to mark the masses on the stones.

If using sand, place a small piece of plastic bag on the scale pan and fill it with sand until you have the required mass. Tie the sand in the plastic bag with thread. Use paper and tape to make a label on the outside, marking the mass with pen. These masses can be used in your school.

If using water, use a beam balance from a nearby school to measure the exact mass of an empty water bottle. Add a volume of water in mL equal to the mass in g needed to reach a desired total mass. (The density of water is 1.0 g/mL, so you can use a known volume of water in a bottle to create a known mass.) This can be done precisely by using a plastic syringe. Label the bottle with tape and a pen.

Measuring Cylinder

See the Form I activity on **??**.

Metre Rule

Use: Measuring length, Principle of Moments, drawing graphs
Materials: Slabs of wood, ceiling board, permanent pen
Procedure: Buy one, take it and a permanent pen to a carpenter, and leave with twenty. Measure each new one to the original rule to prevent compounding errors. See also the Form I activity on **??**.

Nichrome Wire / Resistance Wire

See .

Optical Pins

Use: Compass needles, making holes, flying wire
Materials: Office pins, sewing needles, needles from syringes

Plane Mirror

Use: Laws of Reflection, periscope, water prism, super glue, small wooden blocks
Materials: piece of thin glass, kibatari, Optional: small pieces of mirror glass are cheap or free at a glass cutter's shop
Procedure: Light the kibatari so that it creates a lot of smoke. Pass one side of the glass repeatedly over the kibatari until that side is totally black. The other side acts as a mirror. Super glue to small wooden blocks to stand upright.

Resistors

Use: Electrical components
Materials: Old radios, circuit boards, soldering iron
Procedure: Remove resistors from old radios and circuit boards by melting the solder with a soldering iron or a stiff wire heated by a charcoal stove. If you need to know the ohms, the resistors tell you. Each has four strips (five if there is a quality band) and should be read with the silver or gold strip for tolerance on the right. Each color corresponds to a number:

black = 0	yellow = 4	violet = 7
brown = 1	green = 5	gray = 8
red = 2	blue = 6	white = 9
orange = 3		

and additionally for the third stripe: gold = -1 and silver = -2.

The first two numbers should be taken as a two digit number, so green-violet would be 57, red-black 20, etc. The third number should be taken as the power of ten (a 10^n term), so red-orange-yellow would be $23 \times 10^4 = 230000$, red-brown-black would be $21 \times 10^0 = 21$ and blue-gray-silver would be $68 \times 10^{-2} = 0.68$. The unit is always ohms. The fourth and possibly fifth bands may be ignored.

Retort Stand

Use: To hold pendulums, to elevate springs or other objects
Materials: Filled 1.5 L water bottle, straight bamboo stick, tape, marker
Procedure: Tape the bamboo stick across the top of the water bottle so that it reaches out 20 cm to one side. Attach a small clamp if required or hang object directly from bamboo stick.

Scale Pan

Use: Beam balance, Hooke's Law
Materials: Plastic bottle, cardboard box, string
Procedure: Cut off the bottom of a plastic bottle or cardboard box. Poke 3 or more holes near the top and tie string through each hole. Join strings and tie at the top to hang from a single point.

Spring Balance

Use: To measure force applied on an object
Materials: Strip of cardboard, rubber band, 2 paper clips, staple pin, pen
Procedure: Cut a rubber band and fix one end to the top of a cardboard strip using a staple pin. (A stronger rubber band allows for a greater range of forces to measure.) Attach one paper clip near the top as a pointer. Attach the other paper clip as a hook at the bottom of the rubber band. Calibrate the spring balance using known masses. Write the equivalent force in Newtons on the cardboard. (A 1 g mass has a weight of 0.01 N, 100 g has a weight of 1 N, etc.)

Springs

Use: Hooke's Law, potential energy, work, spring balance
Materials: Springs from hardware stores, bike stores, junk merchants in markets, window blinds, rubber bands, strips of elastic
Procedure: Remove plastic covering if necessary and cut to a desired length (5 cm). Alternatively use rubber bands or elastic from a local tailor - these can also be used to calculate a constant of elasticity.

Stopper

Use: To cover the mouth of a bottle, hold a capillary tube
Materials: Rubber from old tires or sandals, cork, plastic bottle cap, pen tube, super glue
Procedure: Cut a circular piece of rubber. If the stopper is being used to hold a capillary tube, a hole can be melted in a plastic cap or rubber stopper. Alternatively, super glue a pen tube to a plastic bottle cap and connect to rubber tubing.

Stopwatches

Use: Simple pendulum, velocity, acceleration
Materials: Athletic and laboratory stopwatches from markets, digital wristwatches

Test Tubes

Use: To heat materials without a direct flame, to combine solutions
Materials: 10 mL syringes, matches
Procedure: Remove the needle and plunger from 10 mL syringes. Heat the end of the shell with a match until it melts. Press the molten end against a flat surface (like the end of the plunger) to fuse it

closed. If the tube leaks, fuse it again. Test tubes made this way may be heated in a water bath up to boiling, hot enough for most experiments.

Test Tube Holder / Tongs

Use: To handle test tubes
Materials: Wooden clothespins, stiff wire, strip of paper or cloth
Procedure: Use clothespins or stiff wire for prolonged heating, or strips of paper or cloth for short-term heating.

Test Tube Racks

Use: To hold test tubes vertically in place
Materials: Wire grid from local gardening store, styrofoam block, plastic bottle, knife
Procedure: Fold a sheet of wire grid to make a table; punch holes in a piece of styrofoam; cut a plastic bottle in half and fill it with sand to increase stability. Or cut a plastic bottle along its vertical axis and rest the two cut edges on a flat surface. Cut holes into it for the test tubes.

Tripod Stands

Use: For supporting containers above heat sources, for elevating items
Materials: Stiff wire, metal rods
Procedure: Bring a sample to a welder or metal worker in town; make sure the stand is not too short or too tall. You can also make your own from stiff wire.

Water Bath

Use: To heat substances without using a direct flame
Materials: , water, cooking pot
Procedure: Bring water to a boil in a small aluminum pot, then place the test tubes in the water to heat the substance inside the test tube. Prevent test tubes from falling over by clamping with clothespins or placing parallel wires across the container.

Wire

All-purpose wire

Use: Connecting circuit components, current electricity
Materials: Speaker wire, knife
Procedure: Speaker wire can be found at any hardware store or taken from old appliances - the pairs of colored wires brained together. Strip using a knife, your teeth, or a wire stripper.

Specific gauge wire

Use: Electrical components, motors, transformers, simple generators
Materials: Copper wire without plastic covering (transformer wire), knife/scissors, matches
Procedure: Scrape or burn off the insulating varnish at any points you wish to make electrical contact. These wires come in a variety of diameters (gauges). A useful chart for converting diameter to gauge may be found here. If the wire is sold by weight, you can find the length if you know the diameter - the density of copper metal at room temperature is 8.94 g/cm^3. For example, with 0.375 mm wire, 250 g is about 63 meters.