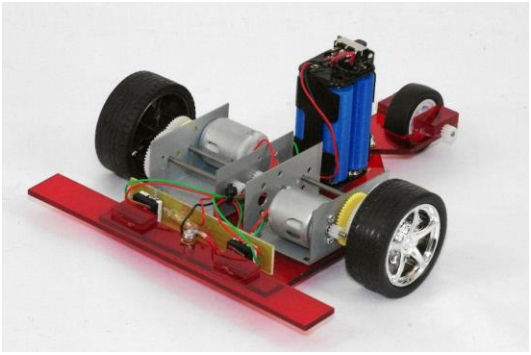
EXPLORER

CONTENTS:

DESCRIPTION



The EXPLORER is a small autonomous vehicle that changes its direction of travel when it bumps into an object.

Two independent motors drive the EXPLORER, each through its own gearbox. The front of the EXPLORER has a bumper bar, which is used to actuate either one or both of the pairs of the bumper bars' microswitches.

Each pair of microswitches control the rotation of the wheel on the opposite side. When one pair is triggered, the corresponding wheel drives backwards, to get the EXPLORER away from the object. The freely swinging trailing wheel introduces a random element to the direction it turns, as well as providing stability. A flashing lamp indicates the approach of the *EXPLORER*.

SECTION 1: GENERAL AND PLANNING INFORMATION

1. DESIGN CONSIDERATIONS

1.1 GENERAL

The prototype *EXPLORER* we built is shown here, but the concept has scope for variation. Refer Section 4 Design for more ideas.

The EXPLORER consists of a platform on which the components are mounted.

Before starting construction, the student needs to plan and lay out all the components (gear cases, battery holder and microswitches) on a sheet of paper or suitable CAD program, and work out the size and shape of the platform, bumper bar and trailing wheel carrier.

- For the vehicle to work well, the designer must look at the vehicle as a complete unit, and not just as separate parts. That means you need to focus on component relationships, rather than dimensions. This provides scope for individual variation.

1.2 ITEMS FOR INVESTIGATION

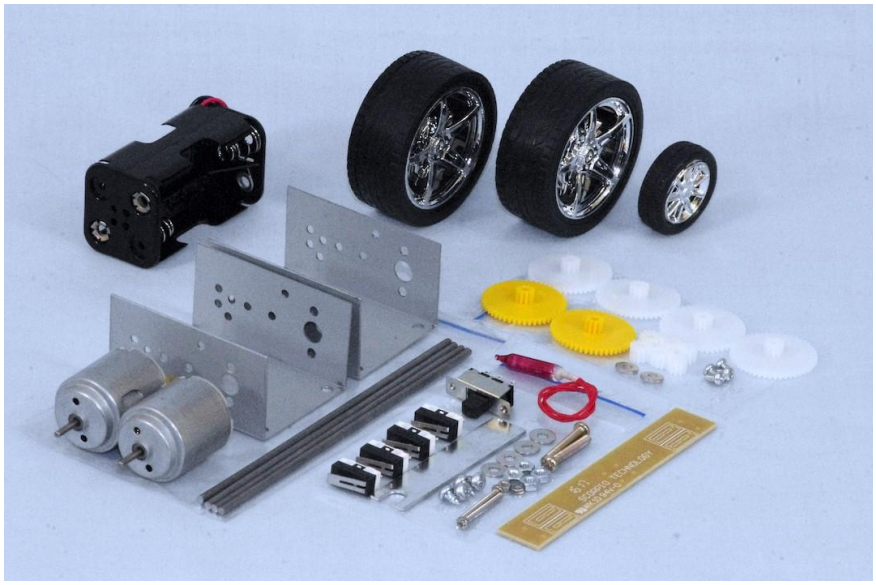
This project provides a number of different aspects of the *EXPLORER* for investigation.

- Evaluate the suitability of various materials, e.g. Aluminium, Perspex and PVC.
- Investigate how much force is needed to activate the microswitches, and how much force the *EXPLORER* exerts when it contacts an obstacle
- Carry out repeated tests, to determine if there is any pattern in the direction the *EXPLORER* reverses in after contacting the obstacle. Is there any correlation between that and the angle it hits at?

SECTION 2: COMPONENTS & MATERIAL REQUIRED

2.1 COMPONENTS SUPPLIED

The following components are supplied in the kit:



2.1 ADDITIONAL REQUIREMENTS

The following items are required and are available from Scorpio Technology, but need to be ordered separately:

- Battery – AA, 4 required (BATTAA)
- Electric hook-up wire – Multi-strand
- Drill Bit – 2.3mm (DB2.3) - for drilling pilot holes for 2.6mm self-tapping screws and the holes for the Bump switch's M2 bolts, as well as providing an interference fit for the 2.5 steel rod
- Drill Bit – 2.6mm (DB2.6) - for pilot holes for the 3mm wood screws which are used to attach the gear boxes, or for holes that need a loose fit for the steel rod, such as the trailing wheel's central hole
- Drill Bit – 3.5mm (DB3.5) – for 3.0mm bolts

The following material is to be supplied by the student / designer:

- Material for the components (PVC or acrylic sheet, plywood, etc.). We used 3.0 mm thick acrylic.

NOTE: Plastic materials can be purchased from plastics suppliers (search the Internet for "Plastics Fabricators" in your area)

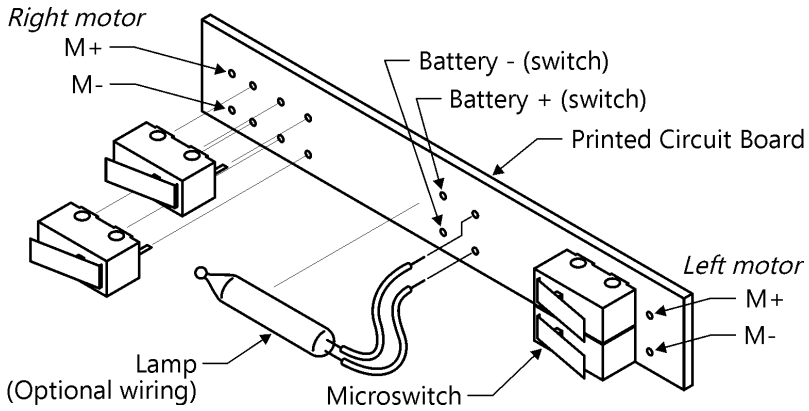
2.2 TOOLS REQUIRED

The following tools are required:

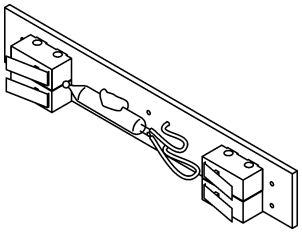
- Assorted hand tools,
- Soldering equipment and solder

SECTION 3: ASSEMBLING THE PCB AND MICROSWITCHES

Assembling the Bump switch PCB is fairly straight forward. There are 4 switches that need to be mounted and soldered onto the PCB.



- Place the switches into the positions shown on the PCB. Make sure the microswitches levers face in the direction shown on the PCB and the drawing.
- Solder the microswitches into position.



SECTION 4: DESIGN

The design needs to take a number of factors into account. Some of the things to consider during the design stage are listed here.

4.1 THE PLATFORM

- The Bumpswitch PCB assembly must be located on the platform's front. It will require two holes, 2.3mm diameter and 65mm apart.

-NOTE: The wiring to the microswitches should be carried out before the bump switch PCB is bolted in place. The PCB can then be connected to the motors, on-off switch and battery holder.

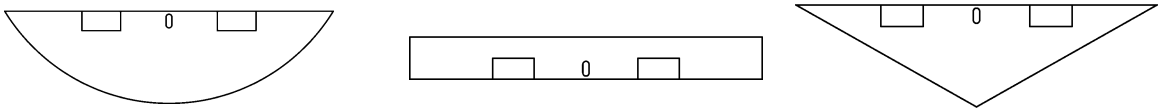
- Ideally both gearboxes should be located with their driving shafts in line, and side-by-side. For ease of construction, or for a narrower chassis, the gears should be assembled on the outside of the gear case.
- Locate the battery holder centrally and just behind the gear cases. The battery holder (rearward) may limit the range of movement of the Trailing wheel carrier.

4.2 TRAILING WHEEL CARRIER

- The trailing wheel carrier's outer edges must be designed to prevent the carrier from swinging too far or the carrier can "jacknife". The carrier's outer edges act as restrictors against the battery holder.
- Provide adequate to allow the wheel to turn freely. A spacer may be necessary on one side of the wheel to centralise it within the carrier.

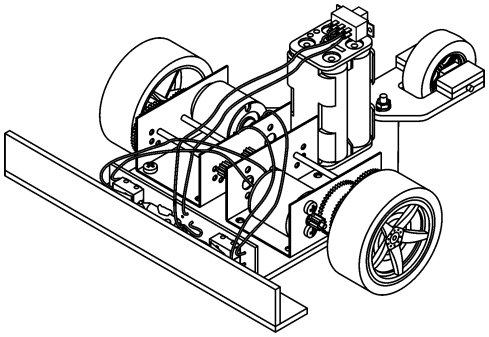
4.3 BUMPER BAR

- The front edge may be straight or curved. Our model was made with a straight bumper bar, but some prefer a rounded or triangular design.



IDEAS FOR OPTIONAL BUMPER BAR SHAPES

- If required, the front face of the bumper bar may be extended vertically. This could be used to prevent the bumper bar of the *EXPLORER* passing under an object that is too low.



- The bumper bar (depending on design) needs to have blocks attached to it to ensure it is thick enough to activate both the switches (to work, both microswitches on one side must be activated).
- Alternatively an "L" shaped bumper could be used to activate the microswitches. Or a "U" shaped bumper can activate the microswitches and provide a vertical front on the bumper.
- The rear edge of the bumper should be just touching the microswitches levers, and be at right angles to the centre line of the platform.
- A slot is required to allow the fore and aft movement of the bumper. The length of the slot (the swivel point) should be equal to or slightly longer than the travel of the microswitches levers.

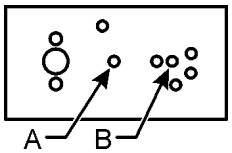
SECTION 5: ASSEMBLING THE GEARBOXES

The *MULTI-RATIO GEARBOX* kit provides a choice of 3 gear ratios to choose from. Before starting assembly, the desired gear ratio must be chosen to suit the usage, as this defines the parts to be used and the assembling procedure.

WARNING: The prototype used triple speed reduction. Faster speeds (e.g. the single or double reduction) will increase the speed of impact of the Explorer to any surface and also increase the possibility of damage to the Explorer.

NOTE: Take care when assembling the gearbox, to assemble the gears to the correct side, as the supplied motor only fits on one side of the gearcase.

5.1 GEARBOX OPTIONS

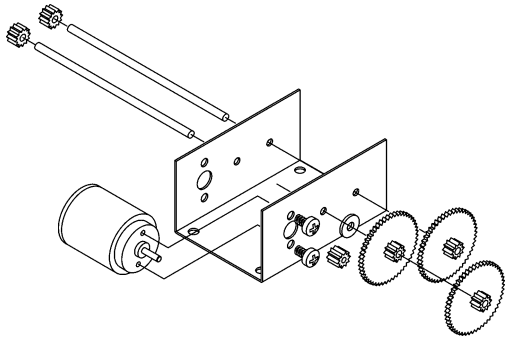
GEARBOX STAGE / Reduction ratio	OUTPUT SHAFT	RATIO	
Single reduction	Hole A	1:5	
Double reduction	Hole B	1:25	
Triple reduction	Hole A	1:125	

Standard Motor (MOT17) - Rated at 4.5V	Performance
6 Volts: i.e. Powered by 4xAA batteries	12,600 rpm ##
Torque	17.9 g.cm

Motor speeds quoted are approximate rpms under load

5.2 ASSEMBLING THE GEARBOX

5.2.1 GENERAL



- For this gearbox, the holes marked 'A' & 'B' in the drawings are to be used - the available gears will not function if fitted to any other holes
- The 10T pinion gear (which has a 1.9mm hole) is press fit on to the electric motor's 2.0mm shaft
- The 12T pinion gears are used as locators.
- The white spur and 12T pinion gears (which have a 2.4mm hole) are press fit on to the 2.5mm shafts while the yellow spur gear is freewheeling on the shaft and has a 2.6 diameter hole.
- The outer two 50T spur gears (i.e. one on each shaft) must be press fit white gears. The inner spur gear (closer to the case) is a free spinning yellow gear.
- The gears can be assembled onto the shaft/s with a help of small hammer.

5.2.2 GEARBOX SELECTION

Before starting assembly:

- Determine the desired gearbox ratio – as this will define which output shaft will be used as the axle.
- Define the length of the axle shaft, and cut (and de-burr) the steel rod to that length.

5.3 ASSEMBLY PROCEDURE:

- Assemble the steel rods, and all the gears, to the gearcase - as shown in the appropriate drawing – double or triple reduction. Also refer to the exploded diagram above.

5.3.2 DOUBLE REDUCTION

- Start by fitting the first shaft to the hole nearest the motor (hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and the (white) 50T spur gear
- Add the second shaft to hole B, and add the 12T pinion gear (locator) and the (white) 50T spur gear.

5.3.3 TRIPLE REDUCTION

- Start by fitting the first shaft to the hole nearest the motor (hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and one (yellow) 50T spur gear
- Add the second shaft to hole B, and add the 12T pinion gear (locator) and one (white) 50T spur gear.
- Install a (white) 50T spur gear on the shaft nearest the motor. For the THIRD reduction ratio, this shaft is the output shaft.

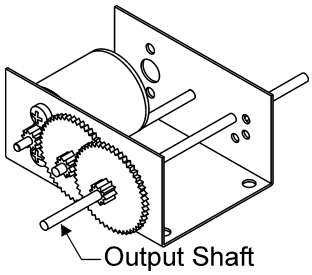
5.4 ASSEMBLING THE MOTOR

- Press the 10T pinion onto the motor shaft. Stop when the worm gear is 3mm from the motor's body.

HINT: Place the gear on the bench, insert the motor shaft into the pinion gear's hole and gently tap the end of the shaft (where it exits the motor) with a small hammer.

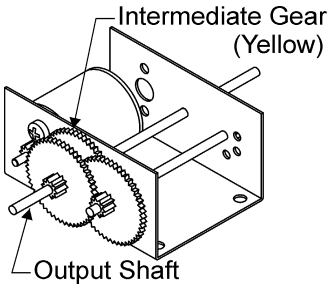
WARNING: Don't just push the motor down by hand, as this can push the motor armature out of its bearings and jam the motor.

- Secure the motor to the gearbox case using the two self-tapping screws.
- Solder a suitable length of wire to each of the motor's terminals. The length will be dictated by the planned location of the gearbox and the other components



DOUBLE REDUCTION

(Lower ratio = higher output shaft speed)



TRIPLE REDUCTION

(High ratio = low output shaft speed)

6 ASSEMBLING THE EXPLORER

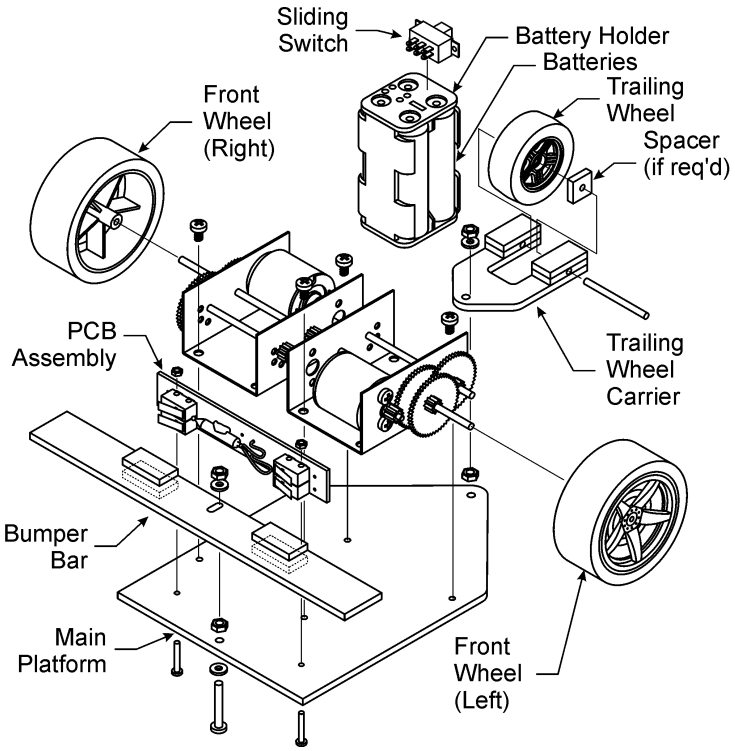
6.1 DRILLING HOLES:

When drilling holes, the following drill sizes are required:

- The 2.3 mm drill is for:
  - drilling the pilot holes for the 2.6mm self-tapping screws
  - providing an interference fit for the 2.5 steel rod (for one side of the trailing wheel carrier) - an interference fit is only required on one side
    - do not do this if using acrylic, as acrylic is brittle
  - drilling the holes for the Bump switch's M2 bolts.
- The 2.6mm drill bit is used for:
  - pilot holes for the 3mm wood screws (used to attach the gear boxes to the platform)
  - the holes that need a loose fit for the steel rod (such as the hole through the 30mm wheel and the other side of the trailing wheel carrier – or, if using acrylic, through both sides).
- The 3.5mm drill bit is used for M3 bolts.

6.2 ASSEMBLING THE PLATFORM

Assemble the components / assemblies as follows.



BUMPER BAR AND PCB:

- The bumper bar is attached to the platform using a centrally located bolt.
    - Use a 20mm long M3 bolt, two nuts (one acts as a lock nut) and two washers so that the bar can swing freely.
- When the bumper bar is in the forward-most position in the slot and at right angles to the centre line of the EXPLORER, place the bumper switch PCB so the levers of switches on either end of the PCB are just touching the bumper bar, but are not operated.
    - Using a fine scriber mark the centre of the outermost holes of each switch. If marked accurately the holes should be 65mm apart.
    - Drill the two holes with the 2.3mm drill.
    - Attach the PCB and switch assembly using the two M2 x 20mm bolts and nuts to fix the switches in place – one bolt and nut per switch pair.

GEARBOXES AND WHEELS:

- Four small holes (2 for each gear case) are drilled in the platform, to match diagonal holes in the gear cases.
    - The 3x5mm wood screws should be inserted from the top of the gear cases and secured to the platform.
      WARNING: Do not over tighten the screws.
- Assemble the two driving wheels to their shafts.

BATTERY HOLDER AND SWITCH:

- Assemble the battery holder to the platform using a hot glue gun or double sided foam tape.
- Use hot glue or double sided foam tape to secure the sliding switch ("on/off" switch) on top of the battery compartment.

6.3 TRAILING WHEEL CARRIER

- The trailing wheel carrier will take the 2.5mm diameter shaft. The fixing of the shaft is dependent on the material used:
    - if using acrylic use a 2.6mm drill bit for both sides, and glue the shaft, or retain it using gears or other retainers to stop the axle moving.
    - with other materials, only one side of the carrier needs to be drilled to provide an interference fit.
- A small spacer needs to be fabricated, so that the wheel doesn't rub on the carrier's inside.
- Assemble the wheel, spacer and shaft to the carrier.

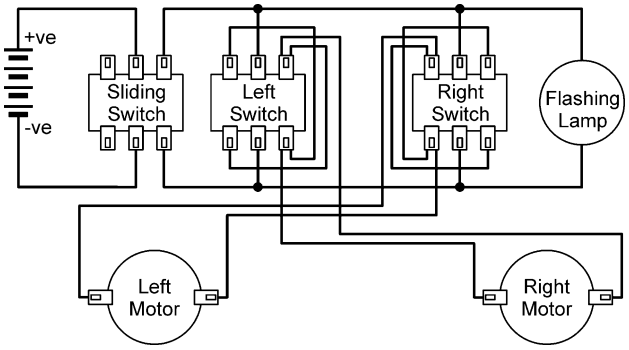
- Assemble the trailing wheel assembly to the platform using one M3 x 20 bolt, a pair of nuts (one nut acts as a lock nut) and a pair of washers. Check that the trailing wheel turns freely regardless of the carrier's position relative to the platform.

7 WIRING

When soldering wires, strip a short piece of insulation from the end of each wire and twist the strands together.

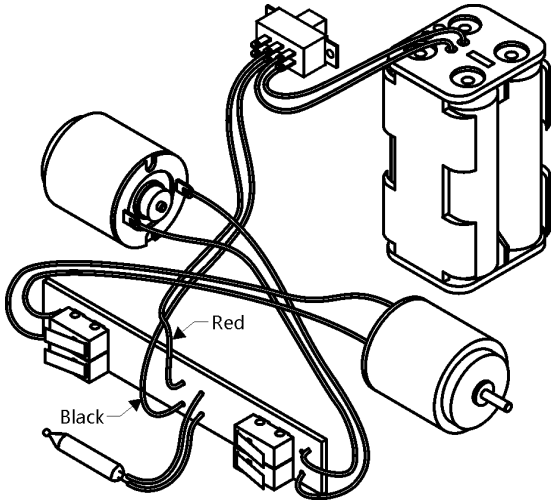
BUMPSWITCH PCB:
See Section 3.4 Bump Switch PCB for detailed information on assembling the microswitches to the PCB.
NOTE: Positive + (RED) and Negative – (Black) are marked on the copper side of the PCB.

BATTERY HOLDER AND ON-OFF SWITCH:
- Connect the Battery Holder to the sliding switch (as shown in the Wiring diagram)
- Connect the wire from the switch to the PCB.
- Solder the wires in position.



WIRING DIAGRAM

CONNECTING THE MOTORS:



WIRING THE CIRCUIT

- Connect wires from the PCB to the motor terminals (use wires approximately 120mm long).

HINT: Use 2 different coloured wires.
  - The Positive connection on the motor is shown with a + symbol next to the Positive terminal on the back of the motor.
  - Use one colour for this terminal and another colour for the other (negative) terminal.
- When looking from the front of the vehicle:
  - the wires from the motor on the right will connect to the bump switch connections on the left side of the PCB.
  - the motor on the left will connect to the connections on the right side of the PCB.
- Connect the Positive wire from each motor to the appropriate M+ connection on the Bump switch PCB.
- Connect the Negative wire from each motor to the appropriate M- connection.

NOTE: It is really important that the switches control the motors on the opposite side of the vehicle. In this manner the EXPLORER will turn away from obstacles and move around them.

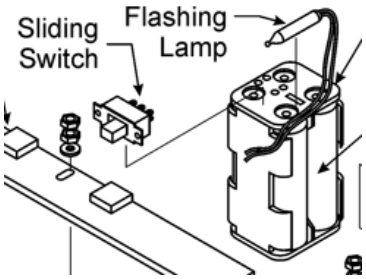
- *Wiring the motors incorrectly will cause the EXPLORER to turn towards the obstacle.*

FLASHING LAMP:

There is a choice of 2 ways to wire up and mount the flashing lamp:

OPTION 1:

- Connect the flashing lamp to the on-off sliding switch as shown in the wiring diagram – by connecting the lamps wires to the terminals at one end of the switch.



OPTION 2:

- There are two holes left near the centre of the PCB. These are available for mounting the flashing lamp. If mounting the lamp at the front (instead of on the battery holder):
  - cut the wires to the lamp shorter and remove about 5-10mm of plastic from the ends.
  - twist the bare wires and insert the wires into the holes on the PCB and solder them. (The lamp will work with the wires connected in either direction).
  - Use a small dab of hot glue to secure the lamp in the chosen location.

8 TESTING AND USAGE

8.1 ELECTRICAL TESTING

After the batteries are inserted, move the sliding switch to the "ON" position. Check that all of the following occur:

- The *EXPLORER* moves forward.
- The flashing lamp flashes.
- When one side (and in turn the other side) of the bumper bar is pushed, the opposite side wheel reverses direction.

If any of the above is not achieved, check the following:

- That the batteries have adequate charge.
- The wiring is connected as per the wiring diagram and instructions
- There are no solder bridges between the terminals
- Bare wire ends do not touch

8.2 MECHANICAL TESTING

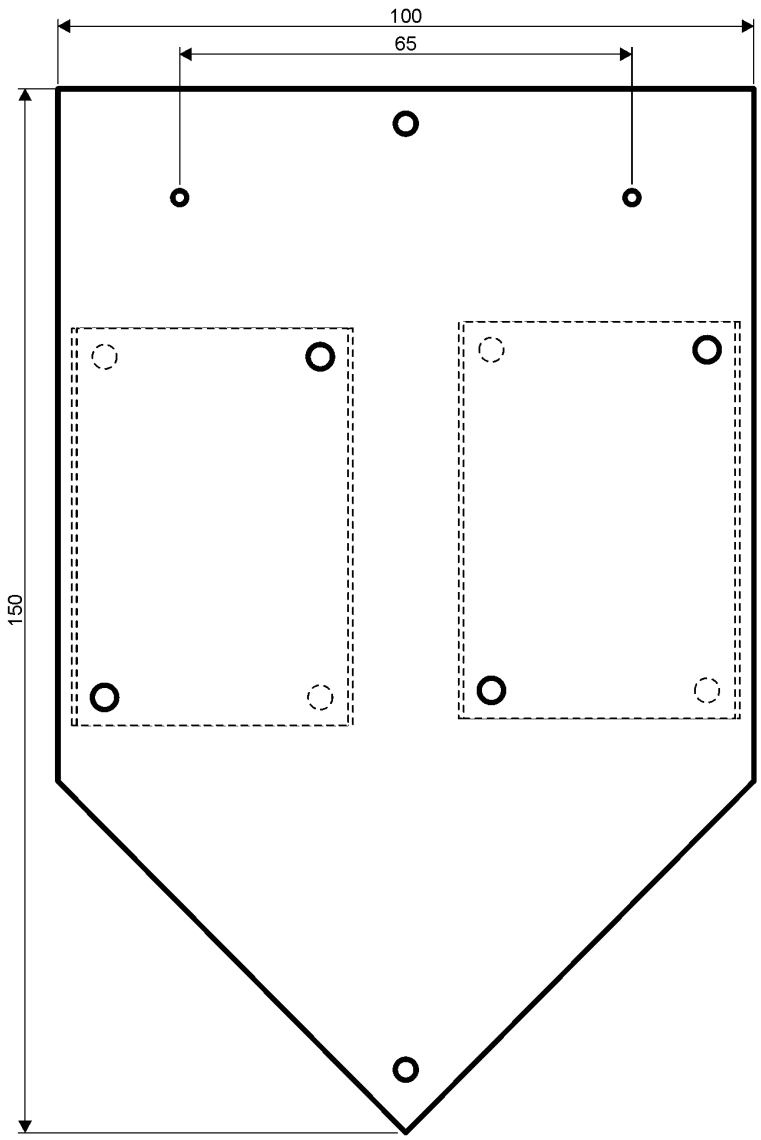
- Check and ensure that the bumper bar can move freely in all directions
- Check and ensure that the trailing wheel carrier and wheel can move freely
- Turn the sliding switch to the "ON" position. Let the *EXPLORER* travel forward until it bumps into an object. The *EXPLORER* should back-up, change direction and proceed on its way.

8.3 USING THE *EXPLORER*

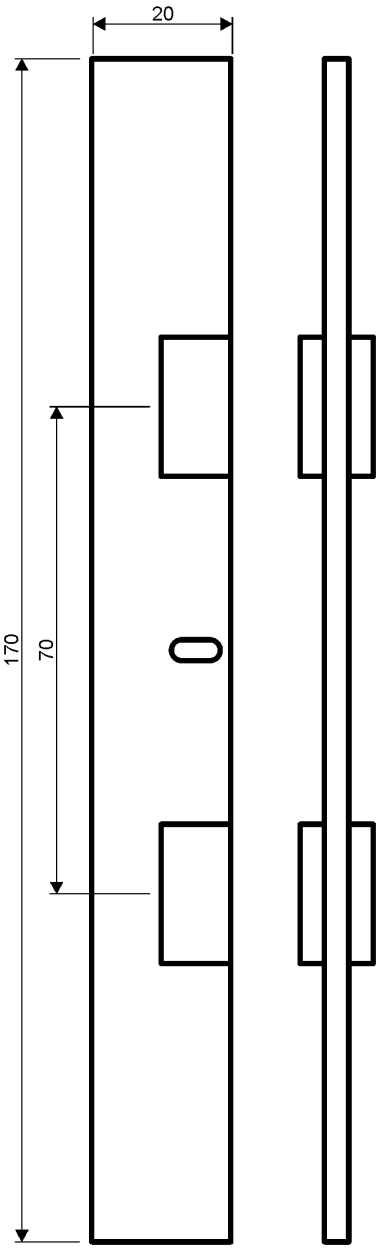
The *EXPLORER* has been completed, tested and is working as it should. Now is the time to use the *EXPLORER*.

How can you use it? The easiest way is to set up the classroom with chairs and other obstacles, and let the *EXPLORERS* loose. Another choice is to set up a board (it prevents the *EXPLORERS* being inadvertently stepped on.

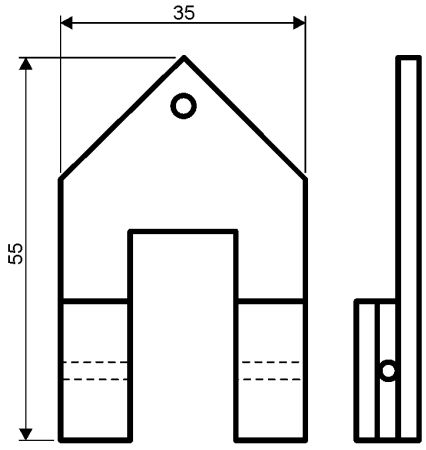
- You can see a sample test board on our website, at: http://www.scorpiotechnology.com.au/kits-in-action/



PLATFORM



BUMPER BAR



TRAILING WHEEL CARRIER

These are the components for the prototype vehicle built for the EXPLORER. The student may change this design as required. Hole sizes and unspecified dimensions are determined by the student.