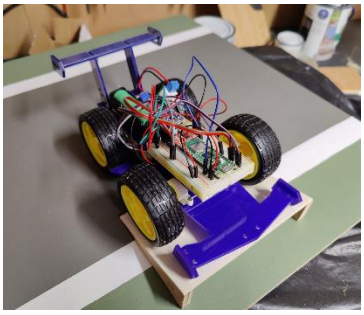
HERIOT-WATT
ROBOTICS SOCIETY

Robotics Society – Kart Workshop

Session 1 – Assembly



Welcome to the Robotics Society Kart Workshop! Over the course of 3-4 weeks, you will be assembling, wiring up, soldering, and powering your very own kart, which can drive around our track, and compete in our **competition on November 20th**, hosted in the National Robotarium!

These instructions are intended to be followed alongside the practical workshop, with RobSoc committee guiding you through each instruction – however they are also produced for those who cannot make the sessions, or want to catch up. Please let us know if anything is not clear!

Following the instructions throughout the sessions will get you a working kart – however it will not be the best you can make! The general kart we designed was built for ease of manufacturing and simplicity, at the cost of speed and control. Thus, it is **up to you** to make changes and make your kart the fastest round our course!

Your choices – Racer or Drifter

First, there are two base designs for the kart, the "racer" and the "drifter", with subtle changes to the assembly and wiring depending on which design you choose. The racer style makes use of four rubber wheels, rear-wheel drive with two motors, and a servo at the to pivot the front wheels to steer. The drifter style makes use of differential trust steering on the front two rubber wheels, and free spinning 3d printed wheels at the rear to reduce friction.

Both kart designs use the same laser cut components, and a majority of the holes and mounting points on the laser cut parts are not used, but are there for mounting any powerups you wish to add, or modifying your kart design without using the laser cutter.

Assembly Steps

We'll start with basic assembly which applies to both karts, then break off into specific assembly relevant to each kart design.

A huge note: Our budget is tight, especially with us not charging membership this year. Cheap acrylic was bought, which has quite a large variation of depth across its surface. Thus, parts can be tighter/looser than intended in the design. A sheet of sandpaper and a needle file can go a huge way, and parts such as the vertical connectors or spoiler are prone to breakage. Don't worry if a part snaps! We have made many spares to account for the variation.

Additionally, various inserts may be stuck inside other pieces – just give them a gentle push with a fingernail or tool and they should pop out.

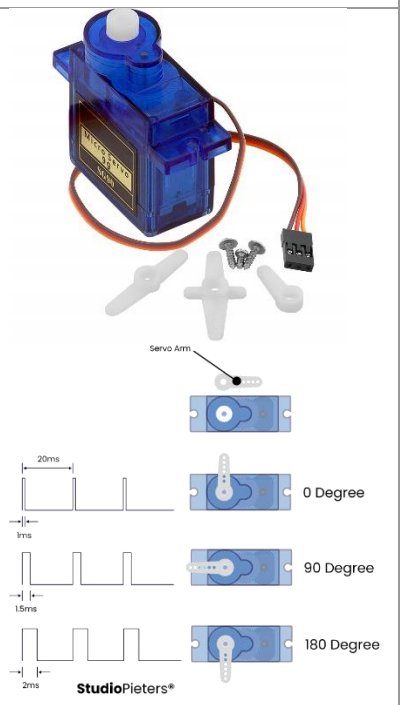
Laser Cut Parts

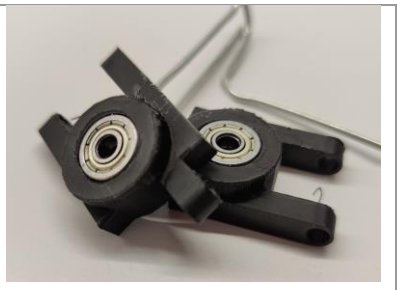
The below kit will be provided, with other parts – not including electronics – are provided either through the society box or the GRID tower (for bolts and wires). See the other parts list below for a full description

Additional Part List

Racer	Drifter
• 4x rubber yellow wheels • 1x sg90 micro servo • 1x half servo horn with 3mm hole drilled at 3rd up • 2x yellow motor (double shaft) with crimped connectors • 2x 3d printed pivot wheel mounts • 2x 12mm 4mm bore shaft bearings • 4x 4mm shaft collars • 2x 4mm 26mm aluminium axle • 1x 2mm steel wire control linkage • 2x M4*16mm bolts (with 4x M4 nuts) • 4x M3*25mm bolts (with 4x M3 nuts) • 1x breadboard	• 2x rubber yellow wheels • 2x 3d printed wheels • 1x 4mm 83mm aluminium axle • 2x yellow motor (double shaft) with crimped connectors • 4x M3*25mm bolts (with 4x M3 nuts) • 2x 4mm shaft collar • 1x breadboard

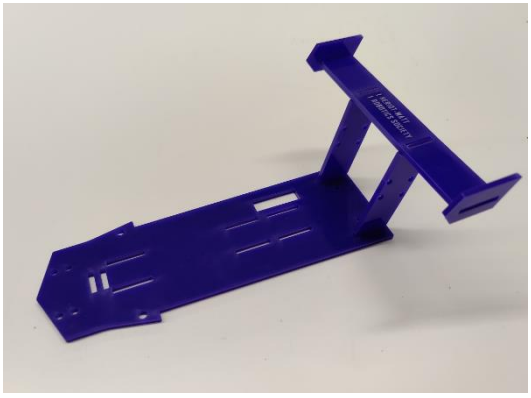
Part Descriptions (for reference)

Part Name	Description/use	Picture
Yellow Motor with crimped connectors	These motors are relatively slow, but with the gearbox addon can produce a reasonable amount of torque. Expect around 90RPM from their output, when given nominal voltage of 4.5V (operating range of 3V to 6V). Motors rotate when a voltage is applied across them, and while modifying their speed via adjusting the voltage is possible, it is far better to modify their speed using PWM signals, and we go a step further by using a motor controller, which will be explained in session 2.	
SG90 Micro Servo / Half servo horn **Learn more about servos and PWM:**	Servos require both a supply through their red and brown wires, but also a signal through the yellow wire. This signal is a PWM signal, which stands for Pulse Width Modulation. By applying short pulses of voltage in a specified pattern, the servo can be made to rotate to and hold a certain angle, which in our case, is between 0 and 180 degrees. In the example to the right, it is shown how adjusting the length of the pulse while keeping signal frequency (50 Hz) the same, can rotate the servo between 0 and 180 degrees. The servo horn is the small piece of plastic that attaches to the end of the gear train, and can attach to your control linkage to pivot the wheels at the front of the racer kart. This piece is incredibly easy to snap – which is beneficial if the servo tries to rotate too quickly, and you'd rather the horn snapped than the servo broke itself. The SG90's that we are using can safely handle up to about 5.3V, and will probably not rotate with anything under 3.3V. Servos can be current hungry when they rotate quickly and with load, easily spiking to 2A. This is the reason a 2S system with step down voltage will be used for the power system.	

3D printed Pivot wheel mounts	These parts are designed to hold a bearing, and connect to both the top and bottom assembly of your kart. They are not optimal, as they rotate about 20mm off the axle connection point. An improvement to your robot could easily be designing a 3D printed piece that connects directly below the axle connection point (hint: there is a pre-made hole in part 1 where this could go!)	
Shaft bearings	These bearings allow for the front wheels of the racer type kart to rotate easily and with less friction. They have an external diameter of 12mm, and an internal bore of 4mm, which fits the aluminium axle. Hint: These could be used on the drifter type cart to allow both rear wheels to spin independently, which would reduce friction further, rather than having both rear wheels mounted on the same axle.	
Shaft collars	Shaft collars prevent the axle from slipping around, and are tightened using an M3 grub screw. The inner bore of the shaft is 4.1mm.	
Aluminium Axle	The drifter kart design uses a single axle at the rear connecting both wheels together, using shaft collars to prevent slippage. The racer kart design uses two axles at the front to connect the wheels to the bearing mounted inside the pivot wheel mount. The aluminium is 4mm round bar, which is relatively easy to bend or grind, with all squared ends done using a bench sander.	

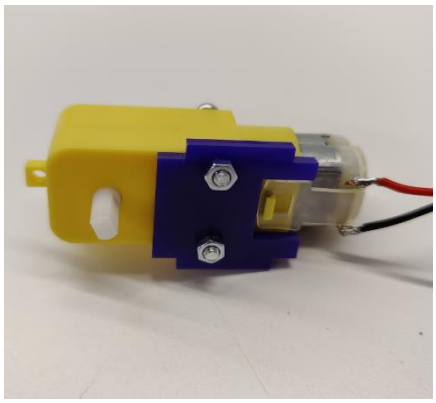
Step 1

Start by assembling the spoiler and top assembly to get an idea of how the parts fit together, and how much sanding is needed. Part 5 (spoiler bars) will slot into part 6 (spoiler), such that the logo is facing up, and the spoiler bars are both heading the same direction. Both part 5's should then assemble together into part 2 (top plate), and form the image you can see on the right. Part 7 can be added as desired to the sides of the spoiler.



Step 2

Each yellow motor should be connected to part 3, with the mouth of the space invader facing towards the silver end of the motor, **and** with the copper solder points of the motor facing towards part 3 as shown. Two 25mm M3 bolts should be inserted through the motor and through part 3, and two M3 nuts placed on the end to hold the piece together, as shown on the right.

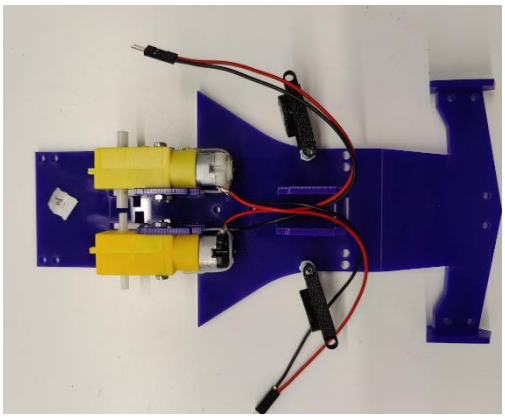


Step 3

Depending on the kit you receive, you may receive motors with pre-soldered connectors, or just copper tabs on the end of the motors. If you have never soldered before, **please come along to one of our sessions**, and we can teach the basics of how to solder onto these tabs. If you know how to solder already, feel free to solder wires of around 15cm length onto these tabs, multicore, with a max AWG of 16 (to enable easier crimping). Once the motor wires are soldered, 2x1 crimps should be added to the end, to aid with connection to the breadboard (RobSoc has crimping tools in the box, or, there should be a crimping tool and crimps per floor of GRID).

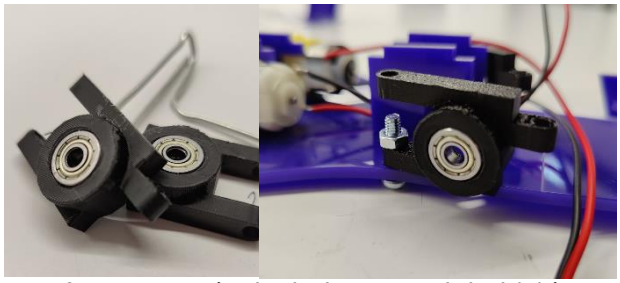
Racer Steps

Step 4



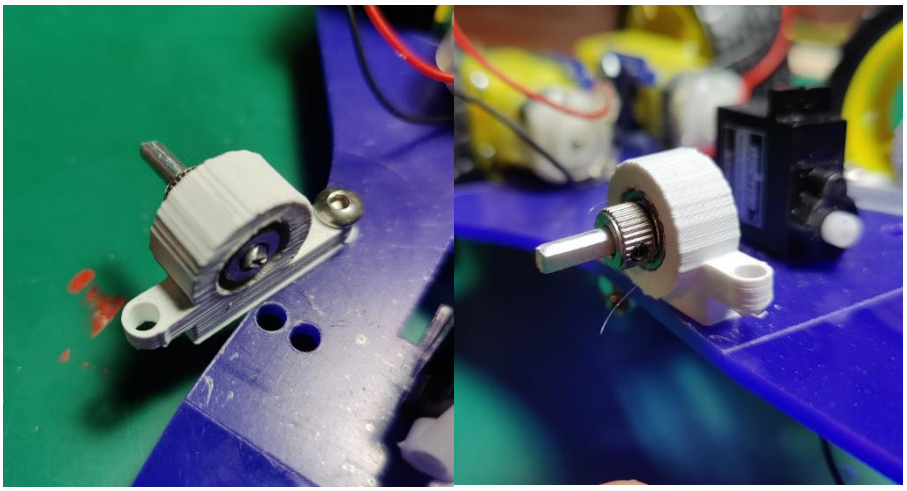
Insert the two motors mounted on part 3 in the rear straight holes of part 1 (labelled b in the diagram of laser cut parts). The end of the motors, with the yellow piece of plastic sticking out, should align with the engraved line on part 1, as shown to the right. Both part 4's can then be inserted into the front straight holes on part 1 (labelled a in the diagram of laser cut parts). Once this bottom assembly is together, you can test fit whether the top assembly that you made in part one fits, or requires further sanding of parts 3 and 4. Then, attach two rubber wheels to the motors at the rear.

Step 5



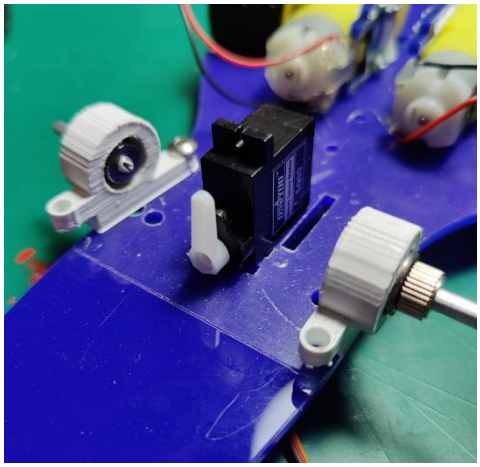
Two 3d printed pivot wheel mounts either in black or white will be included with the kit. Press fit one 12mm bearing into each pivot mount, with the bearing flush with the protruding section of the mount, as shown to the right. Next, these mounts should be attached to part 1 with a 16mm M4 bolt, with the protruding piece of the pivot mount facing away from part 1, in the hole next to label (a) in the laser cut parts diagram, and secured with a single M4 nut. Once you are happy with the positioning, a second M4 nut can be used to tighten the two nuts against one another, preventing vertical movement of the pivot mount, but allowing rotation.

Step 6



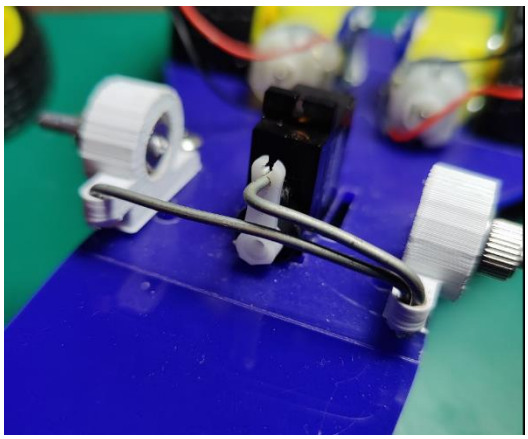
Position one 26mm axle through each of the bearings, such that the chamfered end is facing away from part 1. On each axle, place a shaft collar either side of the bearing, and tighten the grub nuts so that the axle extends no further past the end of the shaft collar.

Step 7



Mount the servo with the single armed horn (white piece that attaches to the rotating circle on the servo) in the centre straight holes of part 1. There are two position options, depending on how you design the control linkage in step 8, and we recommend the rear option. **A key note**: is that the servo may have been rotated prior to mounting, and you cannot guarantee that the position you put the horn will be the centre of the servo. Thus, always ensure in your design that you can remove the servo horn from the servo itself.

Step 8



Connect the servo to either pivot rod ends using a control arm, made from steel wire. This design can take many forms, with benefits and drawbacks to each, and is a key point where upgrades can be made to the kart, for example, using multiple moving components to implement Ackerman steering. The example shown to the right creates a relatively large turning circle, and by changing the attachment point on the servo horn, a smaller circle is possible, by increasing the pivot range.

Some additional details: You want the wire to be able to rotate within each of the pivot rod ends, and rotate within the servo horn itself. The servo horn will also need drilled out to 2mm if using the steel wire supplied, which is best done very slowly, and using just friction and a bit of force, though, don't worry if it snaps at the end, this is usually okay, unless it snaps closer to the horn connector.

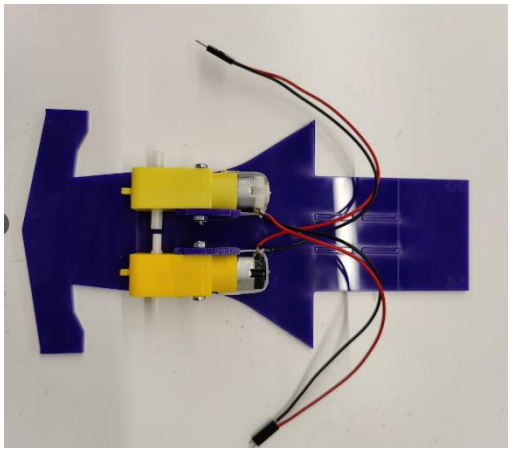
Step 9

Attach the top assembly onto the bottom assembly, and mount two rubber wheels onto the ends of the 26mm axles. If they are loose, they can be secured by hot gluing a small blob onto the wheel hole, then inserting the axle and letting the glue set. Attach part 7 to the front of part 1 and sides of part 6 as desired, then assembly of the racer type kart is complete! Next steps are beginning wiring and electronics, covered in session 2.

Drifter Steps

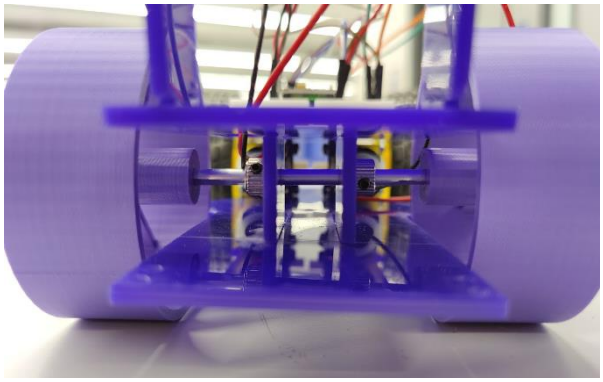
Step 4

Insert the two motors mounted on part 3 in the front two straight holes of part 1 (labelled a in the diagram of laser cut parts). The end of the motors, with the yellow piece of plastic sticking out, should aligned with the engraved line on part 1, as shown to the right. Both part 4's can then be inserted into the rear straight holes on part 1 (labelled c in the diagram of laser cut parts). These should be inserted with the centre hole higher, otherwise the kart will be unbalanced. Once this bottom assembly is together, you can test fit whether the top assembly that you made in part one fits, or requires further sanding of parts 3 and 4.



Step 5

Insert the supplied 4mm*84mm axle through the two holes in part 4. Then center and secure it using two 4mm bore shaft collars, by tightening the black grub screws in the collar. Then, attach the two 3d printed wheels to the ends of the axle. If they are loose, they can be secured by hot gluing a small blob onto the wheel hole, then inserting the axle and letting the glue set.



Step 6

Attach the supplied rubber wheels to the motors at the front of your kart, and part 7 to the front of part 1 and sides of part 6 as desired, then assembly of the drifter type kart is complete! Next steps are beginning wiring and electronics, covered in session 2.