

Greenpower
INSPIRING ENGINEERS

IET The Institution of
Engineering and Technology



INSTRUCTION MANUAL

Introduction to your Goblin Kit Car

- Welcome to your Goblin. We hope you enjoy the Greenpower experience!
- The key objective of building a Goblin is to encourage an appreciation and understanding of engineering and technology by the pupils involved.
- If you have a large number of pupils involved we suggest that you divide them into a number of teams of two or three pupils such as: Chassis Team, Drive System Team, Front Axle Team, Steering Team, Wiring Team, and Bodywork Team. Each team can then operate separately from the others coming together for final assembly.
- The method of assembly is basically clean and hence the project can take place in a classroom safely.
- Remember that the chassis will quickly become full size and will need to be stored in the dry.
- Please ensure that pupils are carefully introduced to the tools used (see over), and ensure they use the correct tools for the various jobs.
- Before any driving takes place, please read the Test Driving and Driver Training page of this manual.

If you require any help whatsoever, please do contact us – we are here to help! Try asking a question on our online discussion forum at **www.greenpower.co.uk** - there are plenty of Goblin experts out there to help!

E-mail – helpline@greenpower.co.uk

Phone – 01243 552305

Important health and safety notes

- Although the kits are designed to be built by 9-11 year olds there are still some potential risks when working with tools and electricity.

Batteries –

- The batteries are AGM type batteries, so cannot leak or spill, making them a safer battery option.
- Caution must be taken when the batteries are out of the boxes, as the terminals are constantly exposed – we recommend that the batteries are kept in their boxes when they are not being used in the car.
- Please be aware that a metal object dropped across the terminals can cause the batteries to short – which can be dangerous.
- They cannot be charged like normal batteries. Only use the slow or trickle charge setting on a battery charger, or acquire a battery charger that is limited to 14.1 volts charging rate.
- Never leave them discharged, and always remove from charge as soon as they are fully charged and return them to their storage boxes.

Tyres –

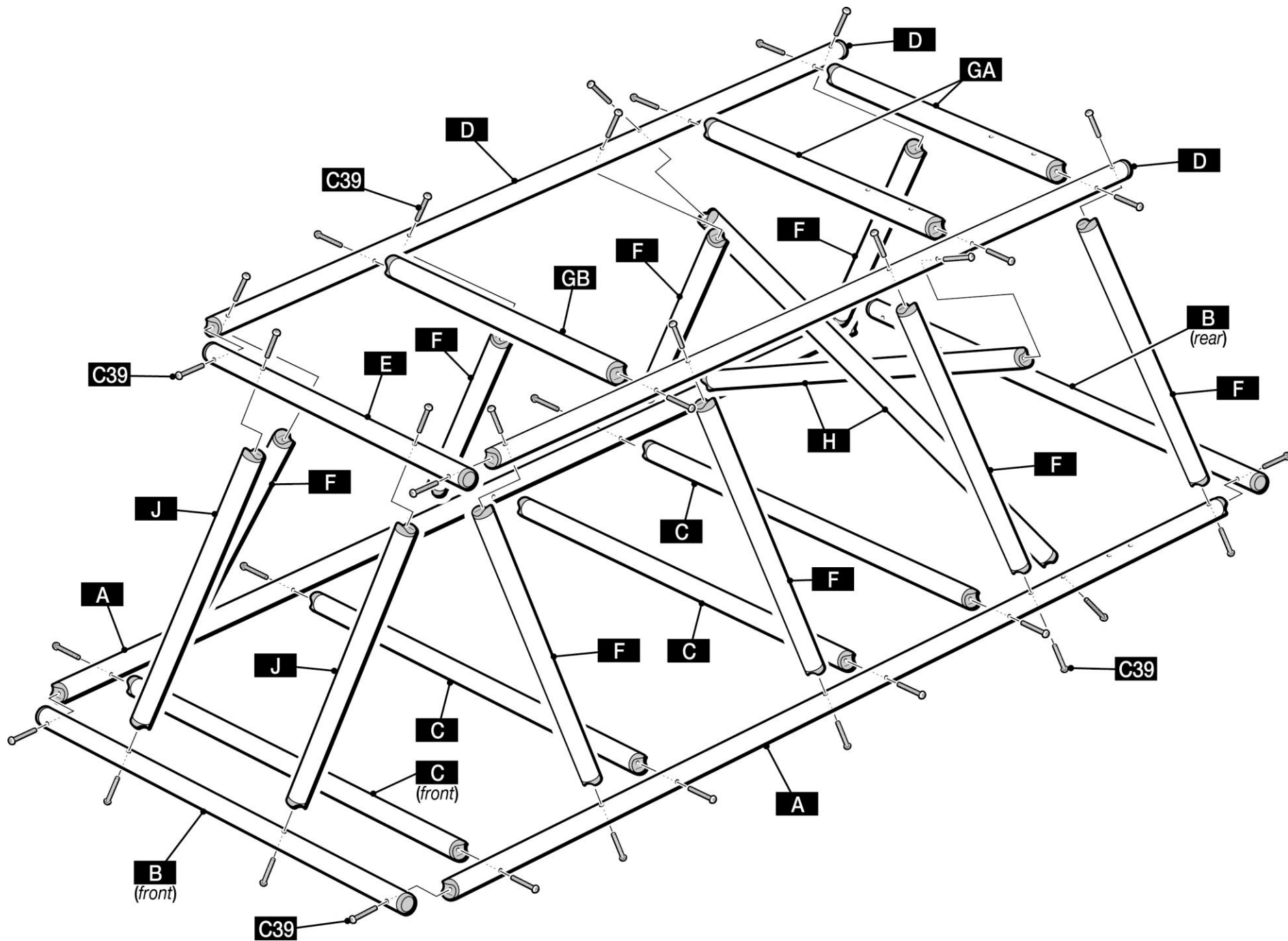
- There is a risk of tyres bursting if they are over inflated.
- Please pay attention to the recommended tyre pressure on the wheels you have, as each batch can differ.
- Do not store the wheels in direct sunlight, over heating of the tyres can cause them to burst.

- Tools you will need:
 - Allen key selection. A 'T' bar type 5mm key is recommended for the chassis screws
 - Battery powered drill with drill bit selection (3mm and 6mm required)
 - Screwdriver selection
 - Assorted Metric spanners – 8mm, 10mm, 13mm and 19mm in particular
 - A small adjustable spanner may be useful!
 - Pliers
 - Small Hammer
 - Electrical sticky tape and cable ties
 - Fine flat file
 - Fine 'wet and dry' abrasive paper (800-1000 grade)
 - Masking Tape
 - Electrical Insulating Tape
 - *Recommended* - Light oil such as 3-in-1
 - *Recommended* – Thread Locking Compound such as Loctite Threadlock
- You will find the best general order of assembly is in the order of the following diagrams. Don't forget to contact us if you need any help or advice, or if you think any parts are missing.
- We recommend you do not open any packets until you need them so you reduce the risk of losing/misplacing parts

Safety First

Always wear goggles when drilling or using other hand tools. Keep long hair tied back.

- Start with the bottom frame of the chassis. Lay the two tubes marked A on the floor (**they are left and right handed so be careful here**), and place the tubes marked C between them as shown. One of the C tubes has a hole through it, and this one needs to go at the front, with the hole pointing up towards the back. Start inserting the chassis screws (C39), and gently tightening them using an Allen key.
- Then add on the Front B tube, with its middle two holes pointing up towards the back, and the Rear B tube.
- Then do the same for the top frame. The D tubes are left and right handed like the A tubes. Make sure you have the GA tubes with the holes on the left hand side. The GB tube should have its holes pointing up towards the front and the isolator connection holes on the right. **It is important the 6th holes from the back (where A2 the roll bar fixes) slant backwards.** Add on the E tube with its middle holes pointing up towards the back.
- At this point C33 can be slid onto tube A and taped into place between the fixings for the back two C tubes. The clips can alternatively be opened and fixed later on.
- Take the bottom frame, and fit the F tubes so they are on top of it, and all pointing inwards. **Don't tighten them up quite yet!**
- Now put the top frame on top of the F tubes, and put the rest of the screws in. Add in the front J tubes.
- The two last tubes are the H tubes. These go behind the seat but in front of the front GA tube.
- With the H tubes loosely in position you can start to tighten up all the screws, checking that the top and bottom frames look square to each other. Completely tighten the H tubes before moving onto the F and J tubes. **Don't tighten the screws too much as you can damage the tubes!**



Notes for the Front Axle Team

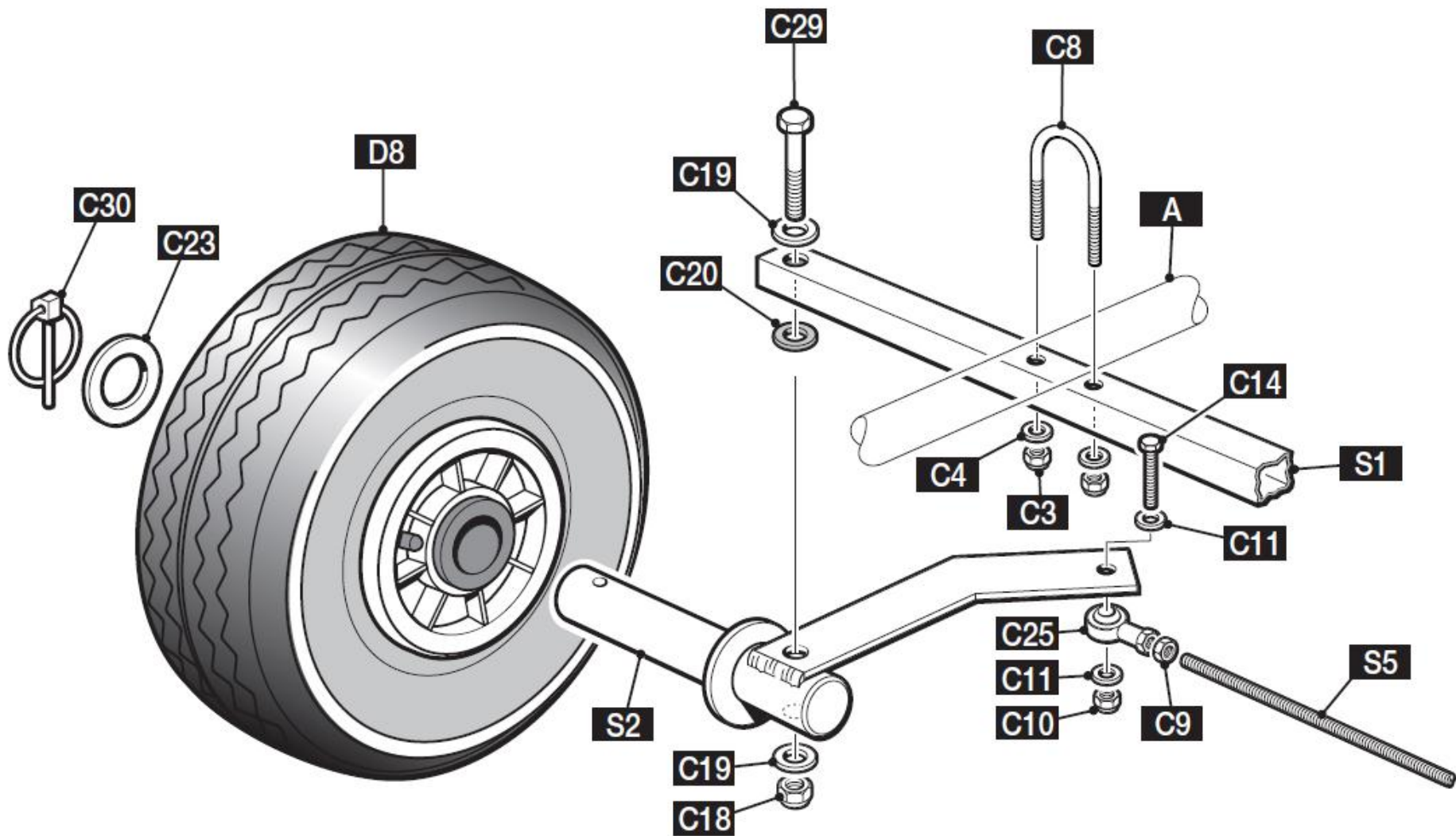
- You can assemble most of the front axle off the car. Start by bolting the stub axles (Part S2) to the square axle tube (S1), as shown (**make sure you have the gold-coloured brass washer (C20) in place**).
- The diagram shows the front right hand wheel. The left hand side is assembled in the same way, but does have a different Part S2 to mirror the other side. Tighten the Bolt C29 until there is no movement up and down, but it can still turn from side to side easily.
- You may find it easiest to have the chassis upside down on a table to fit the axle. The u-bolts (Component C8), as shown, clamp the axle to the A tubes. Only tighten the u-bolts up a bit to start with, as you will not know exactly where it needs to be finally positioned yet.
- Your stub axle assemblies (Parts S2) should now have the flat strip part of them pointing towards the rear of the car on both sides. Do not fit Parts S5 quite yet...
- Have a go at test fitting the wheels. Slide them onto the tube part of the stub axle and follow with C23/C30. Be sure to use the correct wheels as marked.

Handy Tip

When you come to finally fit your wheels, put a small amount of oil inside the centre of the wheel to lubricate the bearings. **You will go much faster!!** You can also smear a little oil on the joints between S1, C20 and S2.

Did you know?

The axle parts of the Goblin have been powder coated. This is tougher than normal paint, and is applied as a dry powder, before being baked in a special oven. Motorbike frames and Rally car chassis' are often powder coated.

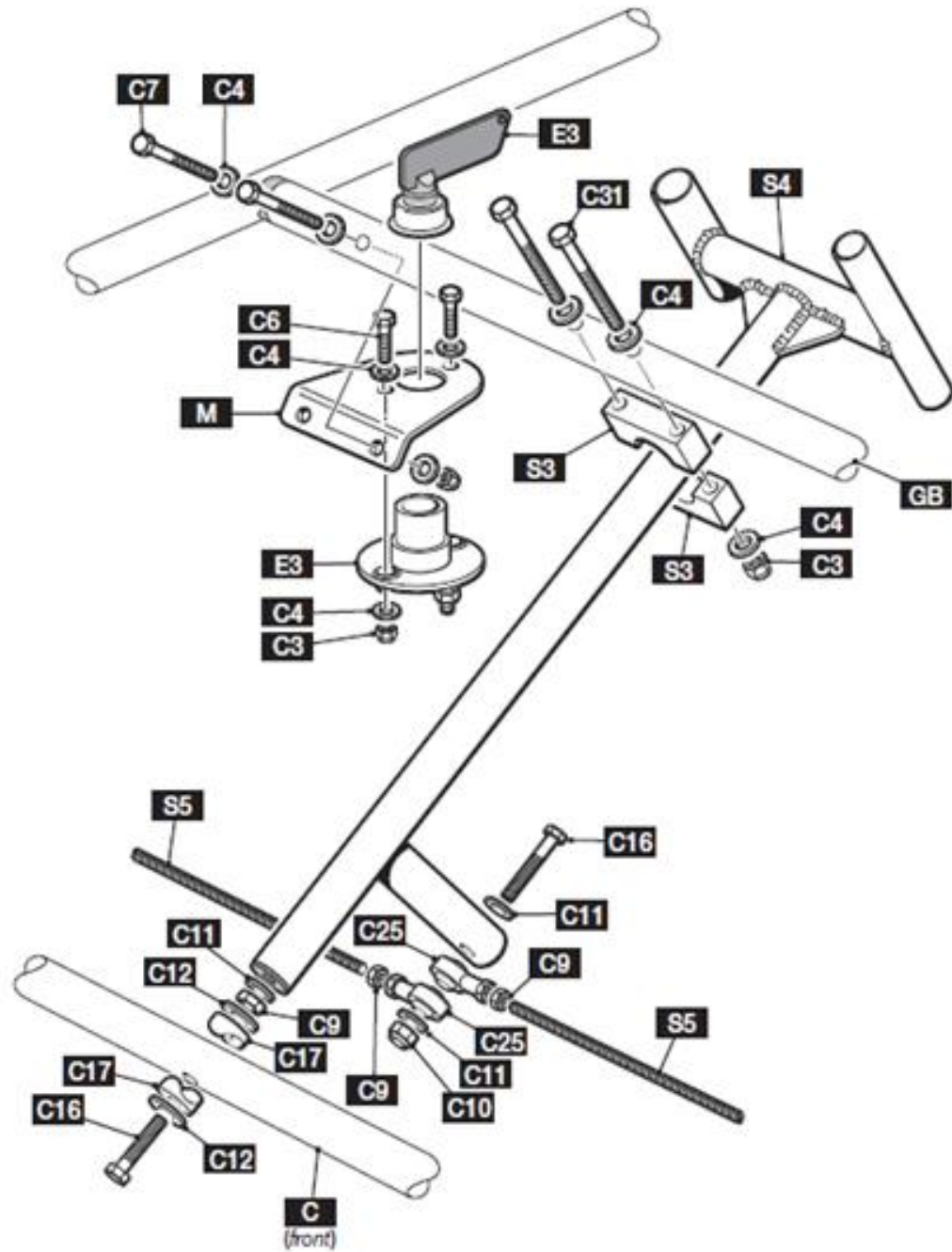


Notes for the Steering Assembly Team

- The steering column is also your steering wheel, and transfers your arm movement to the front wheels.
- Assemble the small components onto the front C tube as shown. Tighten the nut (C9) against the large washer (C12). Screw the whole steering column onto this bolt (C16), until it is close to the washer (C11) allowing not much more than 90 degrees movement left or right.
- Fit the plastic (nylon) column support block (S3) exactly as the diagram shows. If the steering column angle is not correct, carefully twist the front C tube using **both hands** until correct. You might like to put a drop of oil inside the plastic block. The steering should be smooth with no play in it. Tightening or loosening the mounting bolts on Part S3 can alter the resistance.
- Now the steering linkages can be connected. First screw a nut (C9) onto each end of both parts S5. Then wind on the rod end bearings (Parts C25).
- Assemble the fixings for either end of Parts S5 (see the Front Axle Drawings for detail of the outer ends), and tighten the fixing nuts finger tight at first.
- Make sure the steering 'wheel' is in the central position, and both front wheels are pointing straight ahead. If they are not, adjustments can be made by winding the connecting rods S5, into or out of Parts C25. **However, at least 10mm of S5 must be inside Parts C25.**
- When satisfied, tighten up the fixing bolts at both ends, and the back nuts (C9) against Parts C25.
- Fit the drivers isolator line M up with the two remaining holes. Slide a C7 in to each of the holes using a C4 washer either side and tighten using a C3 on each bolt.
- Then you can place the isolator in the larger diameter hole and bolt it to plate M using two C6 bolts, four C4 washers and two C3 nuts.

Handy Tip!

Friction is one of the biggest forces slowing your Goblin down. If your front wheels are not parallel to each other you are creating unnecessary friction which can sometimes feel as bad as driving through sand.

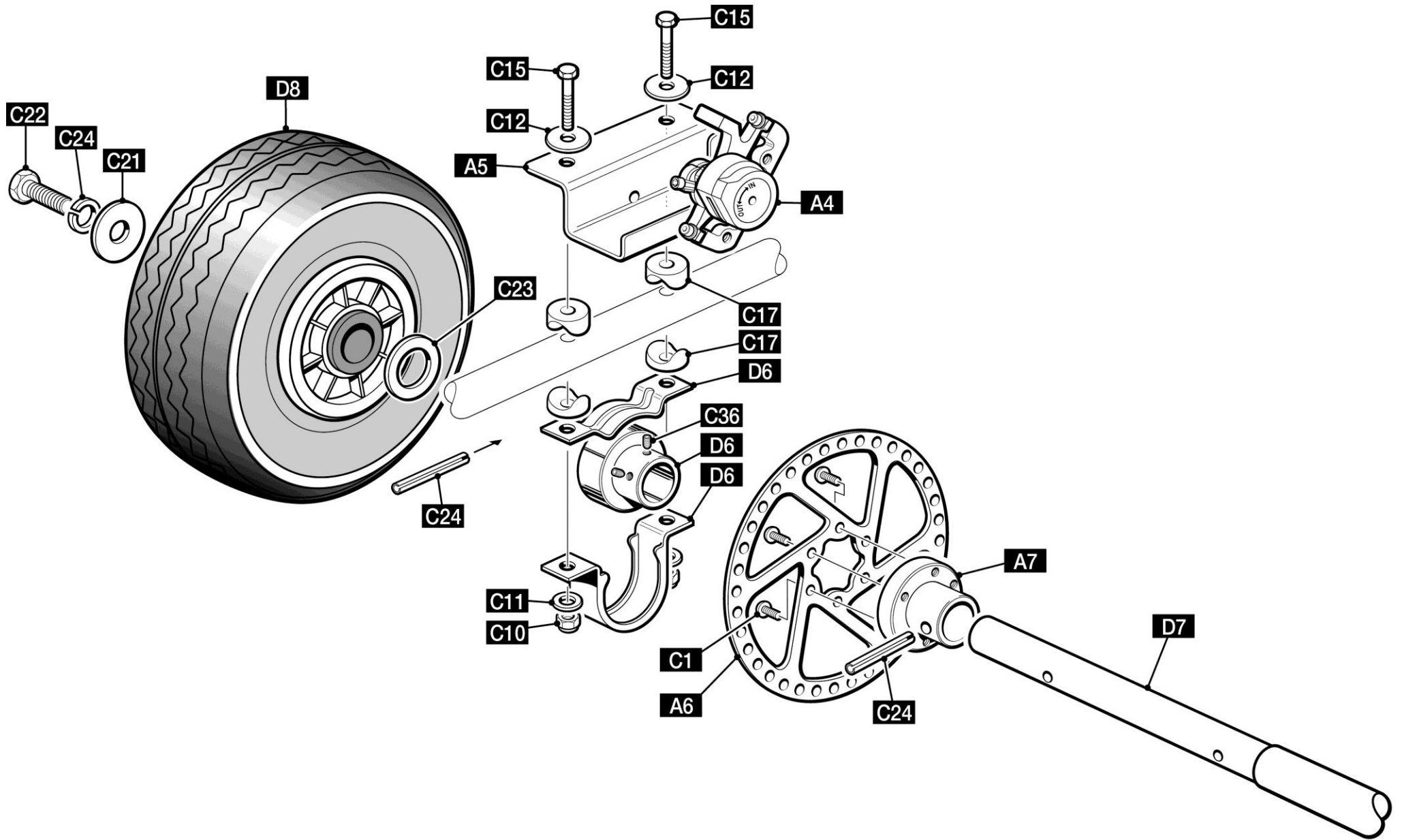


Notes for the Rear Axle Team (Disc Brake Side)

- The rear axle on the Goblin is quite a long job to assemble, and it is important that it is correct, as everything must be aligned for the car to work at its best. Most of the axle can be assembled off the car. **It is a good idea to use a thread-locking compound such as 'Loctite Threadlock' on components like C1, C22 and C36.**
- The right hand side has a wheel the same as the front wheels (D8). The axle on this side has two small holes towards the end.
- Fit part A7 to A6 using the screws C1, then slide it onto the axle as shown until it lines up with the innermost hole in the axle. Tap a roll-pin C24 through the holes having lined them with a small drill bit or similar.
- Slide on the centre part of the bearing, D6. Don't tighten its small grubscrews C36 onto the axle just yet.
- Tap another C24 pin through the outermost hole in the axle, until it protrudes an equal amount from both sides.

Did you know?

The rear axle was made using solid Aluminium and has been shaped by a **Computer Aided Manufacturing (CAM or CNC)** machine which is programmed by a person on a computer to create a more accurate product, but within a shorter space of time than it would possible to, by hand.



Notes for the Rear Axle Team (Driven Pulley & Wheel Side)

- As you will now have the disc of the disc brake on the axle, take care not to put much weight on the axle or you may bend the disc slightly.
- Working from the other end of the axle to the disc brake end, slide on the taper lock bush (D4), with the smaller diameter end of the taper facing outwards. Very loosely place the large pulley (D3) over D4. The two 'half-holes' that are not threaded on D4 should correspond with the two threaded holes in D3. Loosely insert the grubscrews C38 into the corresponding holes.
- Now make sure you put the drive belt D5 around the axle as you will not get it on once the axle is fitted!
- Slide on the bearing D6, exactly how you did it on the Disc Brake Side.
- Tap a roll-pin, C24, through the outer hole in the axle until it protrudes an equal amount each side. **This pin locates in the slot in your drive wheel (D9), and transmits the drive from the axle to the wheel.**

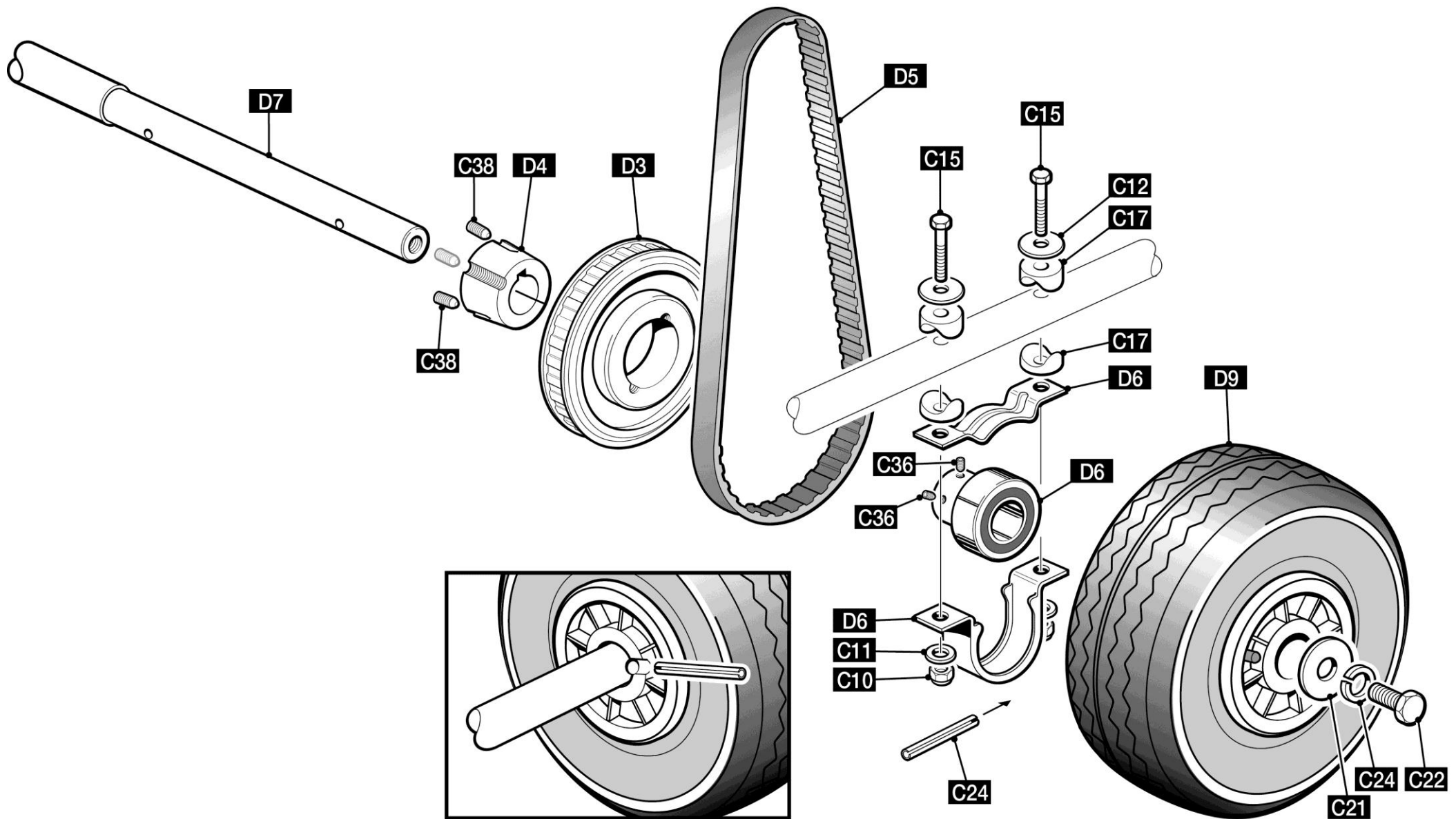
Handy Tip!

To loosen the taper lock bush, D4, remove the two grubscrews C38, and tighten one of them into the third hole (the threaded hole in the taper lock bush D4). This pushes off the pulley and should allow you to move D4.

Did you know?

Changing the D3 pulley for a larger pulley (with more teeth) would 'gear' your car down, and make it slower. A smaller pulley would make it go faster – just like the sprockets on a bicycle, or the gears in a car gearbox.

Remember though that changing any mechanical parts on the Goblin is banned!

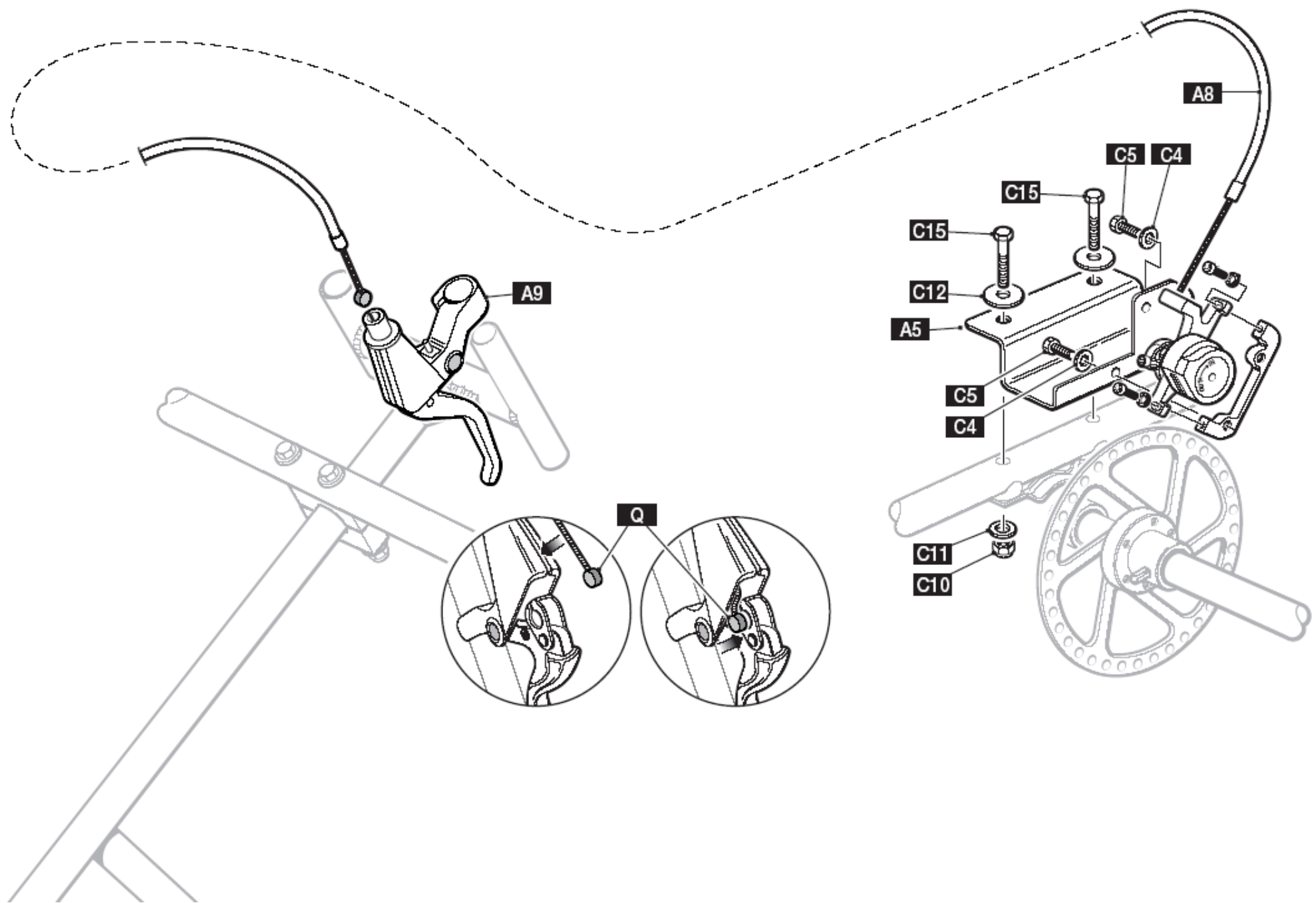


More Notes for the Rear Axle Team (Fitting to Chassis)

- To fix the rear axle to the chassis you may find it easiest to turn the chassis upside down. **Remember that the right hand side of the car has the disc brake and free-wheel (D8).**
- The brake caliper (A4) comes in two parts and will need to be fitted together as shown, using the screws also found in the same packet. Fit the completed brake caliper (A4) to its bracket (A5) exactly as shown in the drawing later in this manual. The C5 front screw is best tightened through the hole in the opposite side of the bracket, and must be tightened now.
- Start on the drive (large pulley) side, pushing the C15 bolts through the chassis from the top, with components C12 and C17 in place. Place the flat part of the bearing (D6) housing onto the bolts. Then place the centre part of the bearing onto this (on the axle), and clamp in place with the final part of the bearing housing and then C11 and C10 – **but do not tighten these yet.**
- Repeat on the disc brake side, ensuring that the brake caliper and bracket are fitted as shown; above the chassis tube A (or under it if you are working upside down!). **Locate the disc brake on the axle between the brake pads in the caliper. The bearings might need moving to be tightened in the correct position.**
- Now tighten up the bearing clamping bolts (C15). Move the axle side to the side gently until it is perfectly aligned in the centre of the brake caliper (A4). **Finally, tighten the bearing grubscrews (C36).**
- You can now fit the wheels as shown. Make sure the drive wheel (D9) has the slot in it **properly located** on the roll pin (C24) at this end of the axle, and you use the spring washer (C43). At the other end, **make sure you have a washer (C23)** between the roll pin and the wheel (D8) – this wheel must be free to rotate. Ensure that the screws C22 are tightened properly – you don't want the wheels falling off!

Handy Tips!

- Many teams place a spare belt over the axle, and strap it to the centre to make belt changing on race days easier and quicker should you snap a belt.
- A race can be won or lost on the extra friction caused by a rubbing disc brake – spend time aligning it carefully!



Notes for Connecting up the Brakes

- By now the brake disc and caliper should be in their final positions.
- Fit the Brake Lever (Part A9) to the steering column, and tighten in your preferred position.
- The brake cable fits to the lever just as it does on a bicycle. Place the end of the brake cable (Q) through the hole in the brake lever (A9). Continue feeding part Q down through the lever, squeezing the handle may make this process easier. Slot part Q into the small hole at the base of the handle for the brake lever. When squeezed, the brake should now pull on.
- Run the cable from the lever down the top right-hand chassis tube (A), keeping all bends open and gentle. Make sure the first bend is big enough to allow the steering to move fully both ways.
- Fix the cable inner at the caliper end using the small screw C42, trapping the cable under its washer. The outer should be located in the caliper body.
- If the cable needs shortening, use a pair of strong wire cutters to cut the inner and outer one at a time.
- Check the function and adjust to suit. When all is ok, tape or cable tie the cable to the chassis tube.

Handy Tip!

The most important thing to remember is that any friction will slow down the Goblin. If the brakes are rubbing on your bicycle, it makes it more difficult to pedal and you might not go as fast... and it is just the same on a Goblin – rubbing brakes will make the motor turn slower, and the car will then go slower!

Notes for the Motor Mounting Team

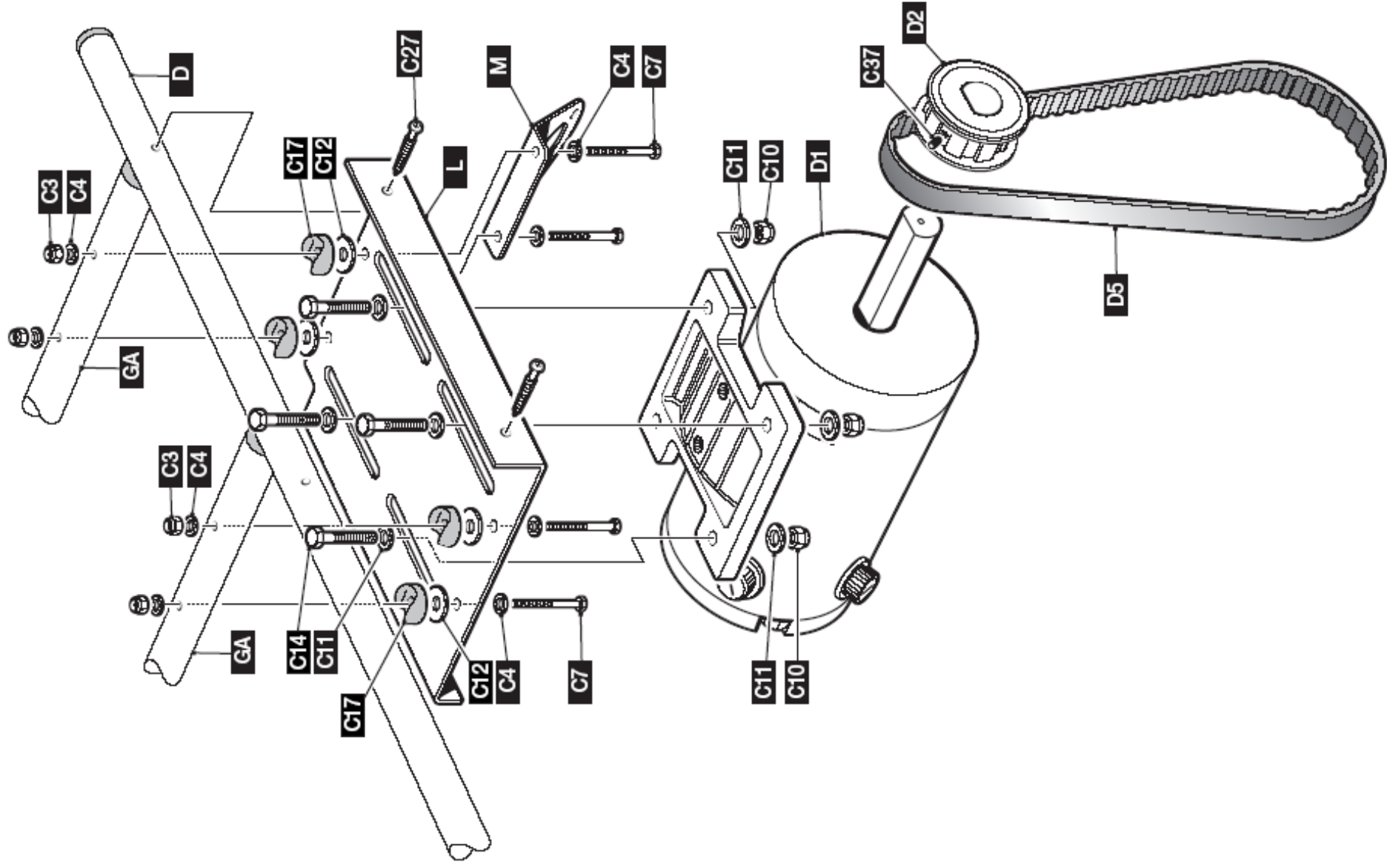
- First of all, bolt the motor mounting plate (Part L) to the GA tubes using the components shown. **Remember that the battery isolator mounting plate (Part M) uses the same fixings at the rear of the Part L.**
- Insert the long screws (C14) into the motor plate slits as shown, using washers (C11). Fix the motor to part L using the washers (C11) and bolts (C10) as shown.
- Slide the small pulley (Part D2) onto the motor shaft, until it is close to the main motor case. Lock the small grub screw onto the **flat part** of the motor shaft.
- When both pulleys are lined up perfectly (see the Handy Tip below), finally tighten the grub screws in the taper lock bush (Part D4), and stretch the belt (D5) on to the pulleys. Tension the belt by sliding the motor forwards or backwards on its screws (C14), until you can't squeeze it more than 10mm between thumb and first finger. **When viewed from the rear the belt should be vertical and the motor horizontal for best results!**

Handy Tip!

Line up the small pulley exactly above the large pulley, by using a straight edge. Move the pulleys on their shafts to find the best position. If the pulleys are out of line it could cause the belt to break, or extra friction, which will make your Goblin slower than some of the others.

Did you know?

The electric motor on the Goblin is usually used in an electric powered wheelchair! (Although the Goblin is of course a bit faster than a wheelchair!!)



Please Note that the motor shaft should be pointing towards the left side of the chassis.

Notes for Fitting the Battery Box

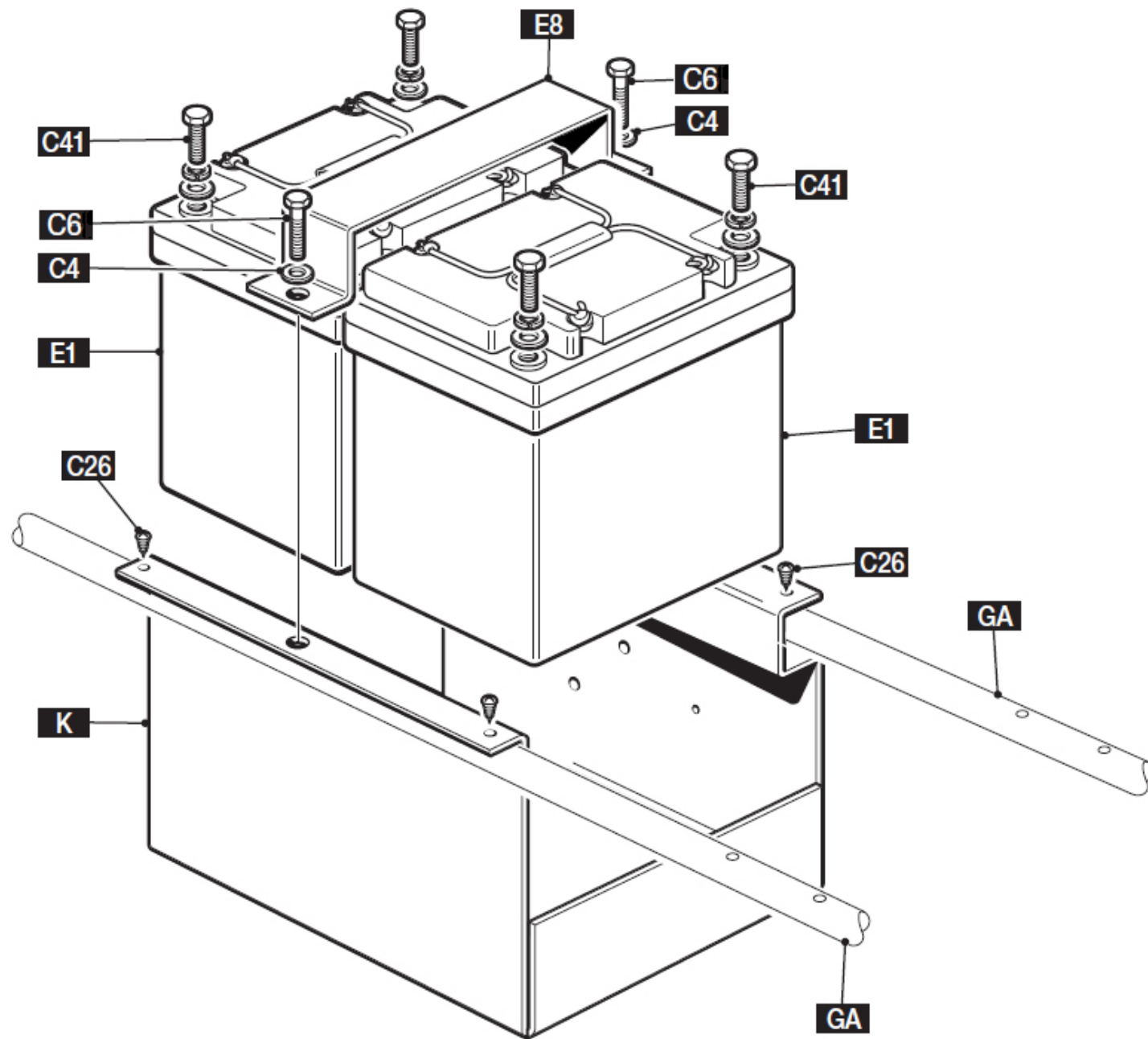
- The battery box (Part K) is easy to fit! You might like to fit the electrical components to it first as shown on the electrical diagram.
- Slide the box in from below the two rear GA tubes, squeezing the box slightly to allow it to hook over the top of the tubes. It should be positioned close to the right hand A tube.
- Carefully drill the fixing holes in the GA tubes, using a drill bit and the six holes in the battery box as guides. **Safety First - Always wear goggles and gloves when drilling.**
- Insert the self-tapping screws (C26)
- Then insert the M6 x 20 (C6) bolts, tighten with a nyloc nut and a washer, and you are ready to put the batteries in!

Handy Tip!

During a wet weather race, water may cause some of the electrical components to not function correctly. You might like to design a plastic cover to keep them dry – it could be part of your bodywork.

Did you know?

You must never place anything across the top of the batteries. Metal objects touching both battery terminals at the same time will 'short-circuit' the battery. Be especially careful when you are transporting your batteries.



Notes for the Wiring Team

- Fix all the Parts to the back of the battery box (Part K) first, looking at the main drawings for positions. (See wiring diagram at back of manual).
- Connect the wires in order – start with the wire labelled *A*!
- Secure the long wires *H* and *J* to the top chassis tube (Part D). To do this you can use cable ties or sticky tape.
- Make sure you leave enough wire for your steering wheel to turn both ways when the *H* and *J* wires are connected.
- When all the wires are connected, get your teacher to lift up the back of the car carefully, and press the button! If all your wires are connected correctly, and the Drive System is complete, the wheels should turn!

Handy Tip!

With your two **12 volt** batteries connected together as the wiring diagram shows, they are working in SERIES. This means that the wires coming out of them are using power from both, and you get **24 volts!**

Because your motor is designed to use **24 volts**, it works at full speed with the batteries connected like this.

If you only connect up one of the batteries you get **12 volts** and the motor works at **half the speed**. This makes the car move at half its usual speed, which can be great for test-driving!

Did you know?

Part E5 is called a relay. It is basically a clever switch which means only small wires need to go to your Push Button. Road cars have loads of relays in them – they switch on things like electric windows, sunroofs and locks.

Notes for Fitting the Floors

- The front floor panels (Parts N) also limit the amount of steering movement, so before fixing hold them in place and see how much steering movement you think you will require.
- Then place the central floor panel (Part P) in position, with the front end of it overlapping the front floor panels.
- Carefully mark and drill fixing holes in the C tubes, using a small drill bit.
- Insert self-tapping screws (C26) and tighten if satisfied the steering mechanism is finished. **If fitting the optional seat belt, do so before finally fitting the floors.**
- Tape over the floor joints with duct tape or similar.

Handy Tip!

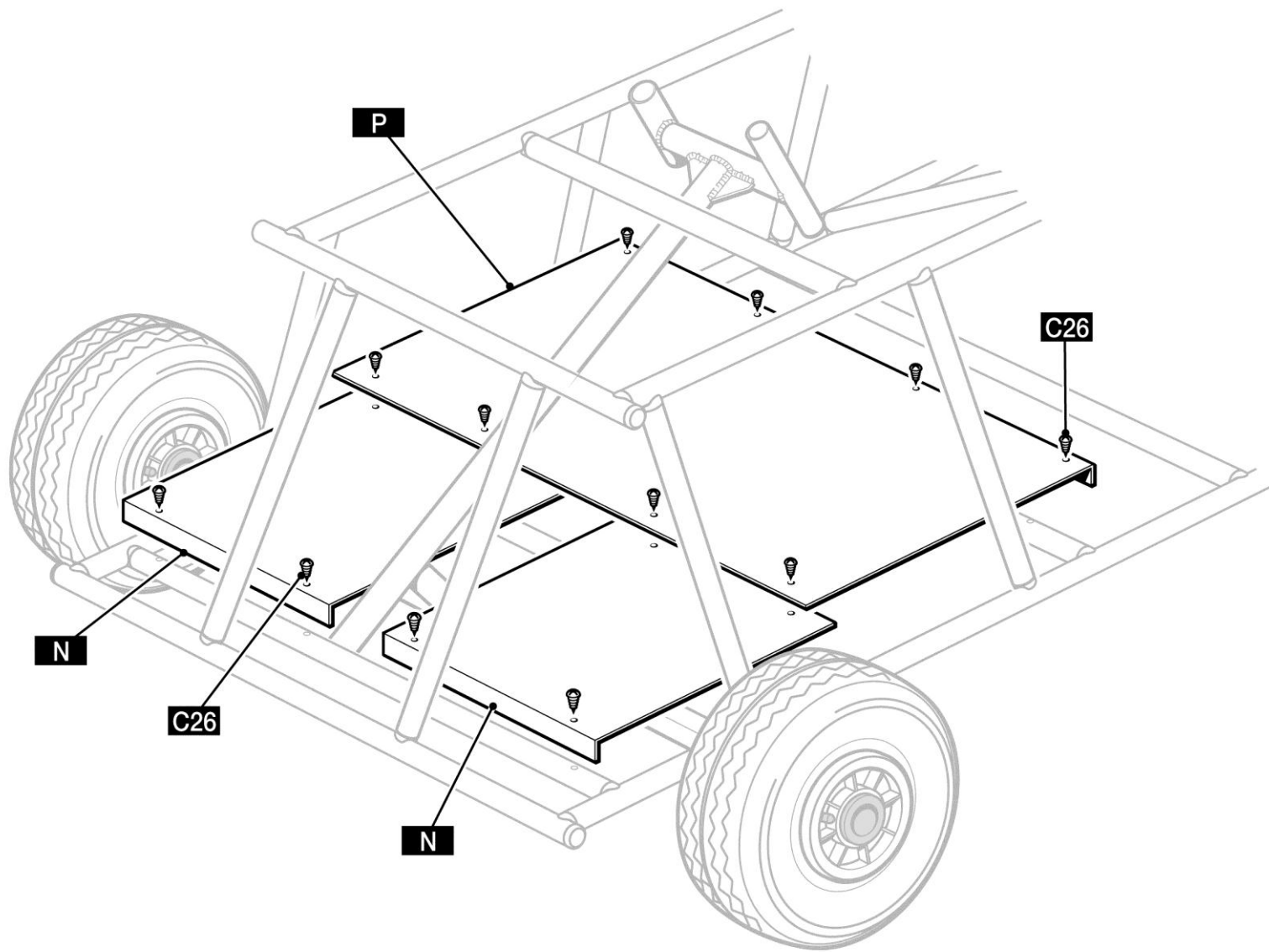
Carefully measure where you need to drill the holes for fixing down the floors – try and make them equally spaced, as it will look more professional! Also make sure they are central on the tube to provide a solid fixing.

If you find the drill bit slips across the floor panels when trying to start drilling the holes, put a bit of masking tape over the area where you will be drilling – this gives the drill bit some grip.

Did you know?

Although Goblins are limited to 15 miles per hour, they use the same motor that secondary schools use to power their own designs of Greenpower 'Formula 24' cars at over 40 miles per hour!

Will you be joining a secondary school that enters Greenpower Formula 24?! Check out www.greenpower.co.uk to see which schools are involved.



Notes for Fitting the Roll Bar

- The roll bar is a safety feature, which hopefully will never be tested in any car. (It also makes a very handy pushing point for starting the car!).
- To mount the roll bar place the roll bar on the D tubes near the back and push a C15 through each side of A2 (ensuring that C12 and C17 are present) as shown in the diagram on the next page.
- Tighten the C15 to secure the roll bar in place.
- The Roll Bar Brace (A1) is fixed using two chassis screws (C35), one in the top, and one at the bottom.

Handy Tip!

With the roll bar removed, you should find the Goblin will fit in the back of most estate cars.

Did you know?

Have you been wondering whilst building the car what a **nyloc nut** is?

Well, nyloc nuts are used in places where a normal nut might come undone by itself due to vibrations, or in places where it is extremely important that the nut doesn't come undone. An example would be on the steering mechanism of your Goblin, or anywhere in an aeroplane!

Have a look at one of the nyloc nuts on your Goblin, such as Component C10, and notice the small blue ring around the inside of the nut at the top. This is made of the plastic nylon, and grips the thread of the bolt you are using it on, preventing it from being undone without using tools.

Notes for Fitting a Seat

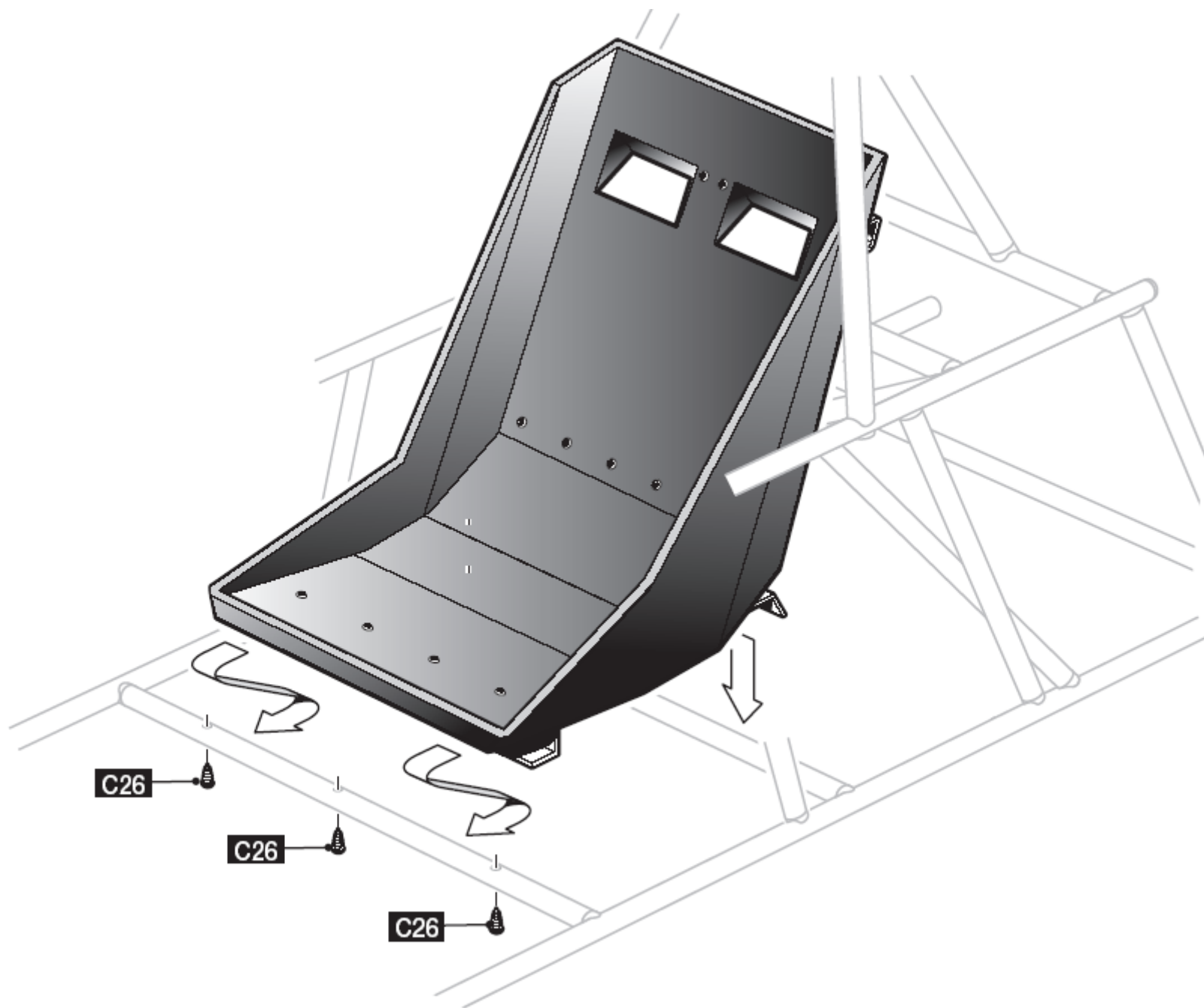
- The Goblin kit comes with black plastic seat which is very easy to fit. The two silver brackets underneath the seat fit over the C tube in front of the H bars and the front of the seat fixing to the 3rd C tube from the front.
- The seat should sit with the back resting against the diagonal H tubes and the base resting on the C tube below.
- Fix the front of the seat using 3 C26 screws. The C33 Q clips used to fix the rear straps of the 4 point harness prevent the seat from moving side to side.

Handy Tip!

Test all the potential drivers in the seat before finally fixing it down. Make sure they can all reach the controls safely. Smaller drivers may need a bit of padding behind their back.

Did you know?

Primary schools have been building and racing Goblins since 2001. There are now hundreds of them right around the country, from Aberdeen in Scotland to Kit Hill in Cornwall.



Fitting a Seatbelt

- The rear straps of the harness should run behind the H tubes, and thread over the C tube at the back of the seat.
- C33 clips are used to fix the 2 rear straps either side of the metal rear seat mounting plate.
- The two side straps are fastened to the A tubes either side of the driver.
- Component C33 is used to fix all four points, with the fixings as shown. C33 will need opening up with a pair of strong pliers, then closing back round the tubes. **Do not drill holes in the tube to fix the seatbelt.**
- The clips supplied may not tighten up fully on the tube, but they will not move once the driver is strapped in.
- Each driver **must** have the straps adjusted to suit their size whilst driving.

Buying Spare Parts

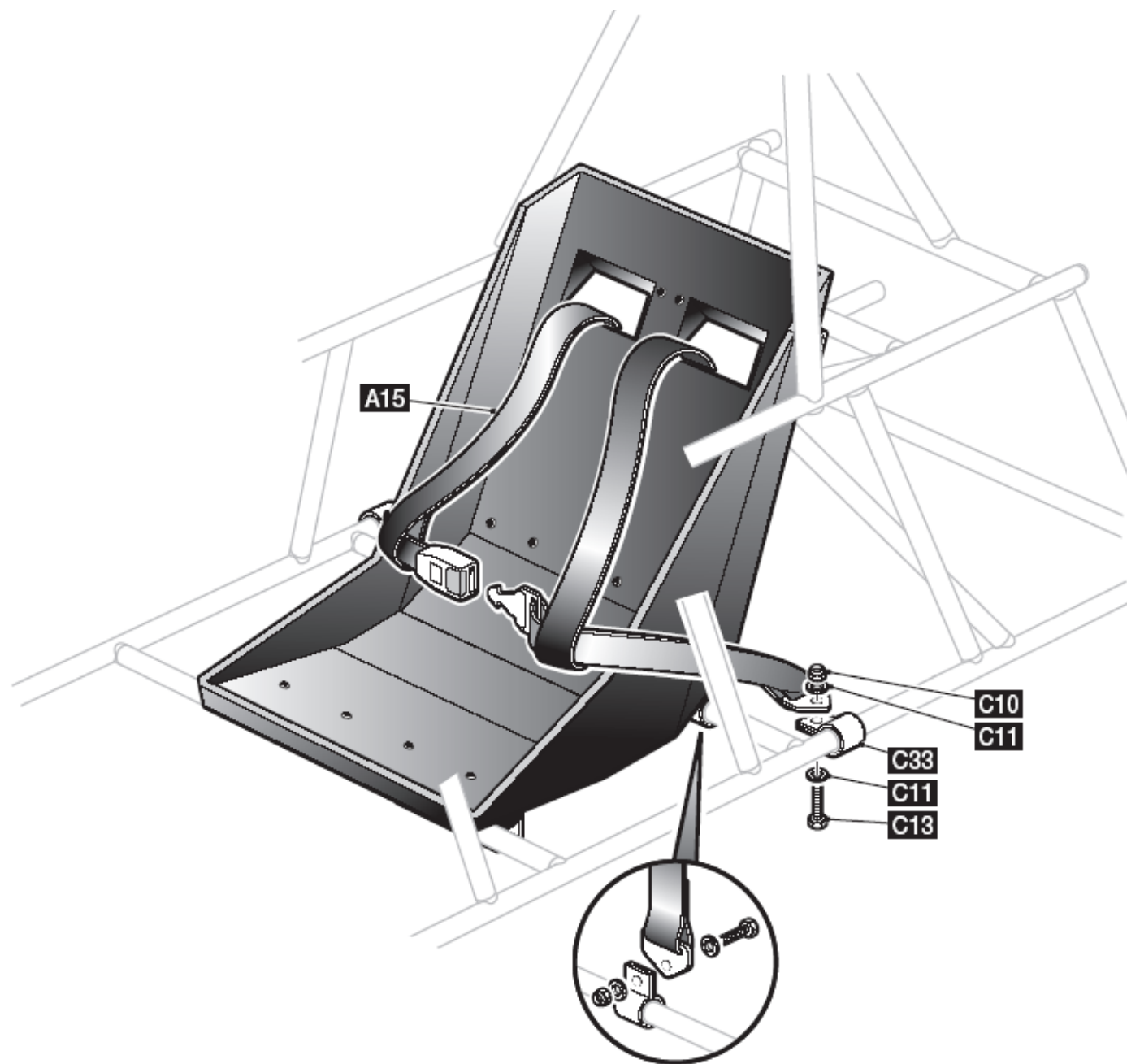
You can order spare parts from us at Greenpower, either check out our website or send your order to:

E-mail – sales@greenpower.co.uk

Fax – 01243 553498

Post – The Greenpower Centre, Arundel Road, Fontwell, West Sussex, BN18 0SD

OR order some items online at www.greenpower.co.uk



Notes for the Bodywork Team

- The bodywork on a Goblin should be decorative, and we leave it to your imagination to do what you want with it!
- The most popular choice of bodywork is 'Correx' or 'Corroflute' (corrugated plastic) which is used to make estate agents For Sale signs etc. But think about alternatives such as foam board, cardboard, Papier-mâché, aluminium sheet or even very thin plywood. **Keep it as light as possible!**
- Try to fix your chosen bodywork on with duck tape or cable ties, as more holes in the chassis tubes will weaken them.
- Make the car looks as individual as possible – you want to look different on race day!
- If you have sponsors for your car, remember to incorporate their logos into the bodywork design.

Handy Tip!

Don't forget you will always need quick access to the big battery isolator switch, and don't make it difficult for the driver to get in and out – you will need to practise pitstops too.

Did you know?

We have seen Goblins with many different bodywork coverings... From flattened coke cans to toilet rolls!!! Some events occasionally have prizes for the team with the best-presented bodywork or most recycled bodywork.

Test Driving and Driver Training

- If you are satisfied the car is fully set-up, try giving it a test drive! The bodywork need not be fully in place for this.
- To start, train each driver in the handling of the Goblin, by pushing the car around quickly with them in the car. Let the driver get used to the steering, and function of the brake. Put out some obstacles and practise turning in and out of them.
- When each driver has tried this, you can conduct the first powered runs. It is important that these take place on a large tarmac or very hard grass area.
- It is usually best to run the car on one battery at first, i.e. 12 volts, until the driver is used to the handling and brakes. This makes the car run at half its usual speed. To operate the car like this, simply disconnect wire F completely, and connect wire G to the positive (+) terminal on the same battery that A is connected to the negative terminal (-).
- Ensure each driver is wearing helmet, gloves, goggles, and long sleeves and trousers. When the driver is comfortable and there is a clear open area, turn on the battery isolator and give the car a gentle push. It should pull away. If there is a prolonged rasping noise from the belt, it is slipping and requires a little tightening.
- The driver should now practise turning in and out of well-spaced cones or markers, freewheeling when turning. At first, practise using the power only in a straight line, and freewheeling in corners.

Important Safety Notice

As well as wearing all the clothing described above, drivers with long hair **must** tuck it into their helmet.

- As we have said throughout this manual, unnecessary friction will slow you down! Go through some final checks before testing, races, and also after each race:
 1. Ensure the brake disc **is not rubbing**. If it is, wind the brake pad adjusters in or out, or adjust axle position.
 2. Tyre pressures. Inflate to the recommended psi on your wheels– never run the car on soft tyres.
 3. Is the belt tension ok? It will loosen after the first few runs and will need re-tightening.
 4. Are the front wheel bearings oiled with light oil?
 - Do not use very thin oils like WD40 as they will wash away all grease or oil and end up running dry.
 5. Are the front wheels parallel? – check with a tape measure between them front and back.
 6. Check the steering movement is free and smooth. Adjust immediately if not.
 7. Is the brake functioning correctly? – It should be capable of locking the rear wheel.
 8. Ensure all nuts and bolts are tightened correctly, including grub screws C36, C37 and C38.
 9. Charge the batteries. Never leave them discharged. (See below).

Important Battery Notice

The batteries are AGM type batteries. This means they cannot leak or spill, and are therefore very safe.

They cannot however be charged like normal batteries. **Only use the slow or trickle charge setting on a battery charger, or acquire a battery charger that is limited to 14.1 volts charging rate.**

Never leave them discharged, and always remove from charge as soon as they are fully charged.

Fault Finding

The most common problem is the motor stopping because the circuit breaker (E4) has tripped. It allows you to re-set it after a few minutes using the red lever. It will trip if there is excessive friction, including running the car on soft ground, or on a very tight course.

If you have **any** other problems, please contact us:

E-mail - helpline@greenpower.co.uk

T – 01243 552305

Ask questions on our forum at www.greenpower.co.uk