Lightning McQueen Handy Operating Manual

TL;DR: Go Faster, Lean Forward, and Keep the Batteries Charged

What to do in case of emergency:

1. Don't panic.
2. Grab the brake. If, in your assumed panic, you forget which handle is gas (green handle, left) and which is the brake (red handle, right): grab them both. The brake switch should automatically force the ECU to cut throttle to the ESC regardless of throttle position.

If the brake handle does not result in a loss of drive power, continue:

3. Turn off the Kill switch above the steering yoke. The kill switch is off when it is pointed up/forward (relative to the steering yoke).

If the Kill Switch does not result in a loss of drive power, continue:

4. Disconnect the battery, located under the hood. Pull the battery-side connectors out from the frame-side connector.

If Disconnecting the Battery does not result in a loss of drive power, continue:

5. Panic.

Important Notes:

If you have questions, you can reach me at j.ashinghurst@gmail.com or at 443.813.1415, or on Skype via my phone number.

See Driving Best Practices, notes 2, 3, and 4 (end of document).

The transponder should be affixed to the front bumper of the vehicle, between the foot rests. Wood screws work to hold the transponder in place

This vehicle's operation depends on a fuse sensor and a speed sensor. If either of these sensors fail, the vehicle will continue to operate but acceleration characteristics, especially from a dead stop, will change in a way that makes Driving Best Practices notes 2, 3, and 4 more critical.

Store the vehicle with the kill switch off and the battery connector disengaged, covered by a tarp or roof if possible.

The horn is functional with the battery plugged in, regardless of kill switch state.

General Operating Procedures:

How to Power On the Car:

6. Plug in battery. Make sure connector is fully seated and that the battery carrying strap is not preventing the connectors from completely engaging.
7. You should hear:
8. Fans for ESC cooling (if the fans do not run, do not drive the car)
9. Water pump for Motor cooling (if the pump does not run, do not drive the car)
10. Release the throttle. The vehicle will not completely boot up while the throttle is engaged
11. Turn on Kill switch. The kill switch allows power to flow to the ESC and motor when it is on, pointed toward the right (relative to the steering yoke). The kill switch is off when it is pointed up/forward (relative to the steering yoke).
12. Several seconds after powering on the system, you should hear a beep from the ESC. After you hear this beep, the system is ready to drive.
13. Engage the throttle.
14. If the vehicle doesn't move, release then repeat the previous step. If you've repeated this step 3 times, call it quits.

How to Swap Out the Battery:

1. Turn off the Kill switch. The kill switch is off when it is pointed up/forward (relative to the steering yoke).
2. Disconnect the battery. Disconnect the battery, located under the hood. Pull the battery-side connectors out from the frame-side connector.
3. Pull the battery out of the vehicle. This should be done in one quick motion by lifting the battery up by the strap while pulling the strap forward toward the front of the vehicle to disengage the spring pins.
4. Put the new battery into the vehicle
5. make sure the battery side rails are engaged properly with the frame receivers
6. drop the battery in such that the battery's spring pins engage with the locking plates on the frame
7. To ensure that the battery is secure, pull the battery strap directly upward. The battery strap should lift the entire front end of the car off the ground, rather than lifting the battery out of the car.
8. Follow the vehicle power-on procedure if necessary.

How to Charge the Batteries:

1. Ensure that one of the X120W chargers is plugged into the 350W power supply, and that one of the X120W chargers is plugged into the 1200W power supply. If both chargers are plugged into the same power supply, they will be unable to charge the battery and you may damage the power supply, chargers, and battery.
2. Ensure that both the 350W and 1200W power supplies are plugged in and powered on (both have power switches).
3. Ensure that both X120W chargers are plugged in and booted up.
4. Ensure that both chargers are set to 4S LiPo balance charge, 10A (information displayed in bar on left-hand side of screen).
5. Ensure that the charging harness is plugged in to both chargers fully.
6. Plug the battery in to the charging harness. Make sure connector is fully engaged.
7. At roughly the same time, hit the 'start' button on both chargers, located in the bottom right corner of the screens.
8. At a 240W pace, the 20Ah battery will charge in approximately 2.5Hr from a full discharge and the 32Ah battery will charge in approximately 4Hr from a full discharge (roughly 1 hour of charge for every 15 minutes of race time).
9. The chargers will not put more than 10Ah into the battery at a time, so check every so often and restart the chargers if necessary.

To restart the chargers:

1. Hit 'OK' to clear the error message, if any exists.
2. On both chargers, if on the graphed charging screens, hit the 'back' buttons to return to the main screens.
3. At roughly the same time, hit the 'start' button on both chargers, located in the bottom right corner of the screens.
4. To stop charging
    a. On both chargers, if on the graphed charging screens, at roughly the same time hit the 'stop' buttons to cancel charging.
    b. On both chargers, if on the graphed charging screens, hit the 'back' buttons to return to the main screens.
    c. Disconnect the battery from the charging harness.

When charging completes:

1. On both chargers, if on the graphed charging screens, hit the 'back' buttons to return to the main screens.
2. Disconnect the battery from the charging harness.

Driving Procedures:

To Go Forward:

1. Release the Brakes
2. Apply the throttle (See driving best practices note 5 where applicable, and notes 1, 2, 3, and 4)
3. The brake switch automatically forces the ECU to cut throttle to the ESC regardless of throttle position. If you are holding the brakes with the throttle held down and you release the brakes, the vehicle will resume acceleration
4. Once the vehicle is moving forward, it is locked into forward until it stops (is moving <2mph), so hitting the reverse button while driving has no effect.

To Stop:

1. Apply the Brakes (red handle, right)
2. The brake switch automatically forces the ECU to cut throttle to the ESC regardless of throttle position. If you are holding the brakes with the throttle held down and you release the brakes, the vehicle will resume acceleration
3. When you are done driving, once the car has come to a complete stop, turn the kill switch off. The kill switch is off when it is pointed up/forward (relative to the steering yoke).
4. Disconnect the battery, located under the hood. Pull the battery-side connector out from the frame-side connector.

To Go In Reverse:

1. Release throttle
2. Stop
3. Hold the “Reverse” Button
4. Apply throttle
5. Once the vehicle is moving in reverse, it is locked into reverse until it stops (is moving <2mph), so you can release the button

Driving Best Practices

1. Moar Throttle – the car behaves better at higher speeds
2. Lean Forward – it may wheelie if you don’t.
3. Lean Forward – leaning forward helps the weight distribution for cornering
4. Lean Forward – Hold your chest as close to steering yoke as possible
5. Before you’re used to the throttle response, it is helpful to be very ginger on the throttle to learn the ‘bite point’ where it starts to engage. The throttle will automatically learn the range of operation as you move the handle through the full range of motion.
6. In the rain, keep it as dry as possible but don’t beat yourself up if it dies.
7. BE AN ATTENTIVE DRIVER. This car has a personality that is very difficult to master, but once you get there the performance difference is night and day.
8. DON’T BE A DICK. You’re faster than ~95% of the field anywhere on the track, so you can get around without resorting to asshattery.

Racing Procedures:

2 Hours before a race:

1. Run through power-on procedure with the battery to be raced, make sure the vehicle boots up and can creep forward and backward at pit speeds
2. Check rough tire pressure by stepping on the tires and ensuring none of them are grossly underinflated.
3. Check tire wear indicators to see how much tread is left compared to how much was left at the start of the weekend.
4. With the battery plugged in, observe the coolant tubing to ensure there are very few bubbles in the coolant system. If air quantity is excessive, bleed the coolant system.
5. Check the wheel alignment by removing the body and making sure that at steering center, each wheel is pointed within a degree or two of straight forward
6. Check steering feel by moving the yoke through its full range of motion to ensure the steering does not feel as if it is binding. If it binds, check that the steering components have not become bent.
7. Check chain tension ONLY with the battery DISCONNECTED. Check chain tension by looking for play in the chain. You should be able to move the loosest part of the chain about a half an inch at most, and should not be able to get it to manually skip a tooth on the small sprocket.
8. Check brake handle operation by squeezing the brakes as hard as you can, then very (very) slowly releasing the handle. The handle should return completely to zero. If it does not, adjust the brake cable to add tension and re-run the test.
9. Pushing the car around the pit should not result in excessive noise from the gearbox or motor of the car. Not really sure how to quantify this – you'll know it if it's acting up.
10. Place the battery to be raced onto the charger and start it charging. Periodically check it and restart the charge to top it off if it has completed
11. Check that the front axle nuts are tight but not overtight. With a properly-tightened front axle nut, the axle spacers between the wheel and the kingpin should be able to rotate but not freely.
12. Check that the pins holding the foot pegs are present and seated.

15 minutes before a race (Gridding Up):

1. Check rough tire pressure by stepping on the tires and ensuring none of them are grossly underinflated.
2. Check steering feel by moving the yoke through its full range of motion to ensure the steering does not feel as if it is binding. If it binds, check that the steering components have not become bent.
3. Check brake handle operation by squeezing the brakes as hard as you can, then very (very) slowly releasing the handle. The handle should return completely to zero. If it does not, adjust the brake cable to add tension and re-run the test.
4. Run through power-on procedure with the battery to be raced, make sure the vehicle boots up and can creep forward and backward at pit speeds
5. Follow the vehicle power-off procedure, turning off the vehicle and disconnecting the battery.
6. Walk the vehicle up to its grid position with power disconnected. Connecting the battery will power on the cooling pump and fan and will drain battery capacity

On the starting Line:

1. Plug in battery a few moments before the countdown begins. If you are nervous, it's better to turn the vehicle on too soon than to turn it on too late
2. Turn the Kill Switch on. The kill switch allows power to flow to the ESC and motor when it is on, pointed toward the right (relative to the steering yoke). The kill switch is off when it is pointed up/forward (relative to the steering yoke).
3. Once the ESC beeps, check proper vehicle function by gently squeezing the throttle until the vehicle moves (make sure the brake handle is released)
4. Once the countdown is underway, follow the launch control procedure (provided again below), leaning back once the countdown is at 3.

After a Race

1. Place just-raced batteries on charger
2. Run the '2 hours before a race' checklist, ignoring the parts about charging a battery.
3. Check motor temperature by placing your hand on the motor. It should not be hotter than a fresh cup of coffee. If it is, make sure the coolant pump turns on when the battery is connected and then bleed all air from the coolant system.

After a Weekend

1. Fully charge and top off both batteries
2. Allow others to drive as time and batteries allow

Launch Control (Advanced Hump Starting):

1. Hold the brakes
2. Apply Full throttle
3. Lean back
4. Still Full throttle, still on the brakes
5. Quickly pull yourself forward toward the steering yoke
6. As you are pulling yourself forward, release the brakes while staying on the throttle, to 'hump start' yourself forward
7. Go! (See driving best practices, notes 2, 3, and 4)
8. (Optional) Look behind and chuckle

Endurance Strategy

1. Start the race with the 20Ah battery loaded and the 32Ah on the charger being topped up
2. For driver changes, the new driver should approach the car from the rear and sit down as the previous driver is exiting the car by stepping forward and into the pit
3. When the 1st-stint driver comes in for the first driver change, the 1st-stint driver should remove the 32Ah battery from the charger and place it toward the front of the pits
4. When the 2nd-stint driver comes in for the second driver change, the 2nd-stint driver should remove the 20Ah battery from the car, and the 3rd-stint driver should load the 32Ah battery in the car and then complete the driver change
5. After the 2nd driver change is complete, the 2nd-stint driver should place the 20Ah battery on charger according to the charge procedure.
6. Make quick driver changes for changes 3 and 4. No more battery changes, the 32Ah will last until the end.

Sprint Race Strategy

1. Run the short Sprint race (30 laps) with the 20Ah battery
2. When the short sprint is done, top off the 32Ah battery
3. Run the long sprint race (45 laps) with the 32Ah battery
4. When the long sprint is done, top off both batteries.

Maintenance Procedures:

All the tools you should need to completely tear apart, rebuild, and service this car:

Screwdrivers:
Flathead screwdriver, stubby (in toolbox)
Flathead screwdriver, Long + sturdy
Philips #2 screwdriver, stubby (in toolbox)
Philips #2 screwdriver, normal length
T20 screwdriver (in toolbox)
Philips #2 ¼" bit
¼" hex bit extension
Wrenches:
Standard Crescent Wrench Set (3/8"-3/4")
Large Adjustable (for 15/16" and 1-1/16")
Don't use a small adjustable, just learn the proper wrench sizes. srsly, this thing uses 3/8, 7/16, 1/2, 9/16, 3/4, and that's it.
Sockets:
3/8" Standard + Metric Sets + Handle
3/8" extension
3/8"-to-hex 1/4" adapter
1/2" Large Standard Set
1/2" handle
1/2" extension
1/2"-to-hex 1/4" adapter
Hex keys:
Standard Dewalt Set
Metric Dewalt Set
Pliers, etc:
Snap-ring pliers
Needle-nose pliers
Channel-Locks (large)
Vise-grips (Large)
Dykes
Power Tools:
Hex ¼" Impact Driver
Misc:
Cable Cutters (in toolbox)
Cable Stretcher (in toolbox)
Coolant Bleed Kit (in toolbox)
Motor coolant bypass (in toolbox)
Chain Breaker (in toolbox)
Patch Kit (in toolbox)
Deadblow Hammer
Air pump

Spare Parts Kept in McQueen's Box:

Turnigy 200A ESC
50A Fuses – 15x
ECU controller (teensy) – 2x
Chain (loose)
Chain (to length with Master Link) – 2x
Chain Master Links – 10+
Chain Half Links – 10+
Motor
BEC (voltage regulator)
Motor/gearbox coupler
Motor/gearbox spider
Gearbox
Brake/Throttle cable – 3x
ECU current amplifier – 2x
1" spacers (various thicknesses)
Zip ties (short
Zip ties (Long)
Coolant – 16oz
Rear Axle Snap Rings

Tools and Procedures to Fix Common Issues:

Straightening Bent Steering (can also be used to replace front wheel)

- 1-1/16" socket with ½" handle
- Channel-Locks, or Big vise-grips, or Big adjustable wrench

1. Remove the front wheel on the bent side with the 1-1/16" socket wrench (don't use an adjustable wrench here)
2. Using the "adjustable-channel-grips", bend the spindle near the tie rod back into shape until the alignment is better
3. Check that the steering can move through its whole range of motion without significant resistance
4. Replace the front wheel. The axle nut should be tight enough that you can still spin the axle spacers by hand, but not loose enough that they spin freely

Proper Wheel Alignment

- 9/16" crescent wrench
- ¾" crescent wrench

1. Loosen the tie rod jam nuts using the 9/16" wrench, while to keep the tie rod from rotating using the ¾" crescent wrench
2. Rotate the tie rod using the ¾" crescent wrench to change its length.
3. Tighten the tie rod jam nuts
4. Check that the steering can move through its whole range of motion without significant resistance

Rear wheel replacement

- Snap-ring pliers

1. Remove the axle retaining ring
2. Remove the rear wheel from the axle, with the key oriented up so it does not fall onto the ground
3. Place the spare wheel onto the car
4. Place the snap ring back in the groove, with the ends oriented in the key slot.

Tube Patching

- Patch kit
- ½" (red/white wheels) OR 12mm (galvanized wheels) socket
- 3/8"-to-hex ¼" adapter
- Hex ¼" Impact driver
- Needle-nose pliers
- Long Sturdy flathead screwdriver

1. Remove wheel from car
2. Remove air from the affected tire using the needle-nose pliers to depress the central valve pin

3. Using the socket, remove all 4 lug nuts from the wheel, keeping track of the nuts and their lock washers
4. Using the long flathead screwdriver as a tire spoon, unmount the tire from its rims
5. Pull the tube out from inside the tire
6. Feel around the inside of the tire and remove any remaining puncture sources
7. Patch the leak

Motor Replacement (can also be used for gearbox replacement or shaft coupler replacement)

- Snap-Ring Pliers
- Needle Nose Pliers
- Motor Coolant Bypass
- 9/16" crescent wrench
- 9/16" socket mounted to Hex ¼" Impact driver
- 3/8" crescent wrench
- #2 Philips screwdriver, normal length
- 2.5mm Hex Key
- T20 screwdriver
- Flathead screwdriver, stubby
- Spare Motor
- Coolant Bottle
- Coolant Bleed Device

1. Unplug the battery
2. Remove the back right wheel (snap-ring pliers)
3. Remove the Chain (needle nose pliers)
4. Unclip the speed sensor (3-pin waterproof connector)
5. Remove the motor from the cooling circuit by pulling the tubing off of the brass right-angle adapters attached to the motor cooling sleeve
6. Place the motor coolant bypass in the cooling circuit
7. Remove the motor mounting bracket from the frame by removing the two 3/8 bolts parallel to the rear axle (9/16" socket and wrench)
8. Remove the motor mounting bracket from the gearbox by removing the two 3/8 bolts opposite each other (9/16" socket)
9. Remove the four screws holding the gearbox to the motor-gearbox adapter (3/8" crescent wrench, Philips screwdriver)
10. Set aside the gearbox so that it does not get contaminants inside
11. Loosen the shaft coupler from the motor shaft through one of the side holes in the motor-gearbox adapter (2.5mm hex key)
12. Pull the gearbox pinion + shaft coupler assembly out of the motor-gearbox adapter (should include gearbox input shaft, gearbox bearing retention washer, both coupler sides, and red coupler spider
13. Unscrew the 4 motor retaining screws from inside the motor-gearbox adapter (T20 screwdriver)
14. Loosen the three phase wires from the 3-pole terminal block (flathead stubby screwdriver)
15. Attach the new motor to the motor-gearbox adapter using the 4 motor retaining screws (T20 screwdriver)
16. Compress the gearbox pinion + shaft coupler assembly so the two coupler halves are as close together as possible, to prevent excessive play in the axial direction.

17. Slide the gearbox pinion + shaft coupler assembly onto the motor shaft until the gearbox input shaft bearing seats inside its retention washer and the retention washer is flush with the gearbox-facing surface of the motor-gearbox adapter.
18. Clamp the motor shaft coupler onto the motor shaft. Clamp it down as tight as you can (2.5mm hex key)
19. Reattach the gearbox to the motor-gearbox adapter using the 4 screws and nuts (3/8" crescent wrench, Philips screwdriver)
20. Reattach the gearbox to the motor mounting bracket using the two bolts (9/16" socket)
21. Reattach the motor mounting bracket to the frame using the two bolts (9/16" socket)
22. Remove the motor coolant bypass from the cooling circuit
23. Reinsert the motor into the cooling circuit
24. Reconnect the speed sensor
25. Mount the chain (needlenose pliers)
26. Mount the wheel (snap-ring pliers)
27. Reattach the 3 phase wires to the 3-pole terminal block in any order (stubby flathead)
28. Power-on the kart by plugging in the battery and powering on the kill switch
29. Check that the wheel spins up quickly (speed sensor not broken) and in the right direction (not backwards)
30. If the wheel spins backwards, exchange any two of the wires in the 3-pole terminal block (stubby flathead)
31. Bleed Coolant
32. Tension Chain

Coolant Bleeding

- Spare coolant bottle
- Coolant Bleed Device

1. Remove the screw top from the coolant bottle and screw the coolant bleed device onto the coolant bottle
2. Uncouple the car's cooling system between the red and black tape, ensuring the reducing adapter remains with the side it had been taped to
3. Attach the bleed device into the cooling circuit, matching the black tape with black and the red tape with red.
4. With the car sitting level, plug in the battery
5. When bubbles stop flowing out of the cooling system, slowly lift the right-hand side of the car until the car is vertical on its left-hand side
6. When bubbles stop flowing out of the cooling system, slowly lower the right-hand side of the car until the car is horizontal again
7. When bubbles stop flowing out of the cooling system, unplug the battery
8. Remove the coolant bleed device from the cooling circuit, making sure all reducing adapters remain with the sides they had been taped to
9. Re-couple the car's cooling system, red tape to black tape.

Chain Tensioning

- ¾" socket with handle
- ¾" crescent wrench

- Dead-blow hammer

1. Unplug the battery
2. Using the ¾” socket and crescent wrench, loosen the bolts holding on the right rear axle pillow block bearing.
3. Use the dead blow hammer to adjust the pillow block bearing until the chain is properly tensioned.
4. Tighten down the pillow block bearing, re-checking chain tension as you do so to ensure tension has not changed as the bolts are reattached.

HANDY-DANDY CHECKLISTS

2 Hours Pre-Race

- ☐ Power-On
- ☐ Move at Pit Speeds
- ☐ Tire Pressure
- ☐ Tire Wear
- ☐ Coolant Bubbles
- ☐ Wheel Alignment
- ☐ Steering Feel
- ☐ Chain Tension (unplug battery)
- ☐ Brake Handle Return
- ☐ Gearbox Noise
- ☐ Top Off Race Battery
- ☐ Axle Nuts
- ☐ Foot Peg Pins

15 Minutes Pre-Race

- ☐ Tire Pressure
- ☐ Steering Feel
- ☐ Brake Handle Return
- ☐ Power On
- ☐ Move at Pit Speeds
- ☐ Power Off

On Grid

- ☐ Power On
- ☐ Creep Forward
- ☐ Launch Control

Post-Race

- ☐ Charge Race Battery
- ☐ Motor Temperature
- ☐ Tire Pressure
- ☐ Tire Wear
- ☐ Coolant Bubbles
- ☐ Wheel Alignment
- ☐ Steering Feel
- ☐ Chain Tension (unplug battery)
- ☐ Brake Handle Return
- ☐ Gearbox Noise
- ☐ Axle Nuts
- ☐ Foot Peg Pins

Post-Weekend

- ☐ Charge Both Batteries
- ☐ Let people drive