

TWIN TWEAKS

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THIS MONTH: Mars Needs Motherships

THE LUNAR ROVER 3-IN-1 PARTS.

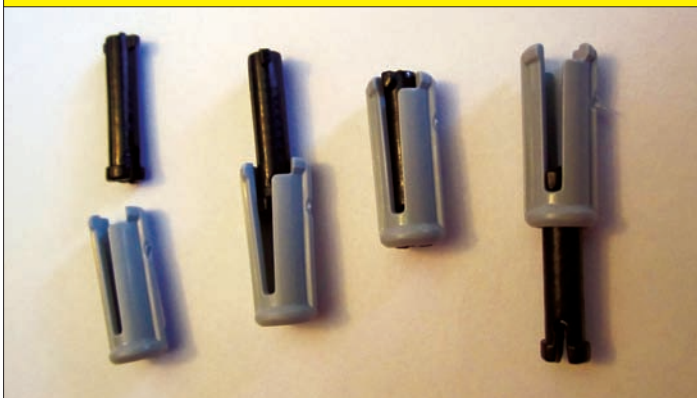


This month, we have the pleasure of presenting the 3-in-1 Lunar Rover kit from MINDS-i. The MINDS-i system — invented by Mike Marzetta — is meant to be an expandable robotics platform that is more robust, powerful, and interchangeable than current offerings. The Lunar Rover itself is a large four wheeled radio-controlled vehicle with rack and pinion steering topped by a sleek solar panel. The 3-in-1 aspect of the kit is that the instruction manual suggests three different configurations for the base of the robot, ranging from a low profile bot suspended on leaf springs to a flexible bot equipped with colorful shocks. Having worked with a range of other robotics kits, we were eager to see what fresh ideas MINDS-i brings to the table.

The Light Side of the Moon

One of the first things you notice about the Lunar

THE MINDS-I CONNECTOR.



Rover kit is the scale. The approximately five inch diameter wheels are the first indication that you're dealing with something truly able to rove over some rough terrain, and the large kit of parts promises fertile ground for independent designs. The large solar panel also promises plenty of power for even large bots. The kit comes with an instruction manual and the website offers some helpful instructional videos that we recommend perusing before proceeding.

One of the numerous innovations of the MINDS-i system is the design of the connectors that hold the frame together. The connectors are comprised of an inner shaft and an outer shell, and operate in a way reminiscent of the cam bolts one uses to assemble do-it-yourself furniture. The core must be pressed into the shaft, and after insertion into the frame the core is turned 60 degrees to lock into the shell. The connectors come in four different flavors — two different lengths, and locking or smooth connectors. The locking connectors constrain the movement of the beams while the smooth connectors allow the connected beams to rotate. Unlike many kits, the Lunar Rover comes with its own set of tools which includes Allen wrenches and a special slotted screwdriver to use with the connectors. The screwdriver has a nib at the end of it that allows the cores of the connectors to be easily removed once pressed in all the way.

With three configurations to choose from, it was tough to decide which incarnation of the rover to build first. We settled on what seemed to be the second configuration. This appeared to be the one with the highest profile which we thought would make it easier to go back and add structural embellishments. The second configuration also

used the eye-catching shocks instead of the unassuming leaf springs for suspension, and we couldn't pass up the cool factor.

The manual recommends putting together the gearboxes and drive shafts first, but we started with the frame so we could get acquainted with the basic parts. Using the connectors and frame bits is very straightforward, and even though we had some initial worries about possible loosening and falling apart, once assembled the frame never gave us any problems.

Embattled in Los Angeles

After crafting what looked like it could have been the start to a sturdy bridge, we turned to the locomotive elements of the bot. Even though the Lunar Rover is a four wheel drive robot, it uses only one DC motor and transmits power to the wheels through drive shafts and differentials. The gearbox for the motor is a very simple assembly, and even though the kit comes with a motor, the folks at MINDS-i tout the rover as compatible with virtually any hobby motor. Such a bold statement is backed up by the adjustability designed into the gearbox – a slotted mount allows the builder to achieve the ideal mesh between the gears with the provided motor, but also would accommodate motors of numerous other sizes. The included motor is a 5,000 RPM DC motor that promises plenty of power thanks to a 5.8:1 gear ratio.

The kit offers two options for the differentials: a traditional differential and a fixed differential. The instruction manual does not recommend one differential over the other, though we thought that the traditional differential would be the better choice for an intrepid rover. The fixed differential would cause inefficient slipping as the rover turns and climbs over terrain. The fixed differential would be better for speed on a straightaway, so we could go back and add it later if we were in the mood to make a lunar drag racer. The spider and pinion gears for the differential are impeccably machined, and fit perfectly in the pumpkin.

The kit wisely recommends for the user to keep track of the side that the ring gear is on before hiding it in the outer casing, and we took the suggestion of identifying the gear side by the heads of the screws holding the casing together. The differential spins nicely, as long as you don't overtighten the screws holding the casing together. The casing is held together only by two screws near the opening for the shaft of the pinion gear. Tightening these screws pinches the casing around the bearings that house the shaft, and opens the casing on the opposite end from the screws. This devilish pinching seems to cause the ring gear to rub against the inside of the casing, making the differential run very roughly.

Luckily, this problem has an easy solution. When installing the differential in the robot itself, it sits in a frame that surrounds the casing nicely. Thus, even leaving the screws on the casing loose runs no risk of the differential



TOOLS OF THE TRADE.

falling apart. The frame keeps everything together well and the differential running smoothly.

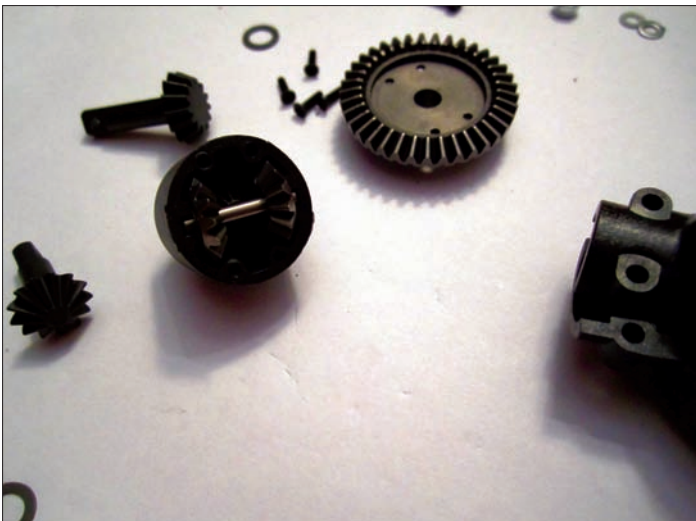
One of the themes running throughout the kit is the necessity of cutting threads into a lot of the plastic parts as you screw them together. This is an aspect of the kit that we had a bit of a love/hate relationship with. On the one hand, we appreciate the fact that this adds to the durability of the kit. Threading the plastic yourself acts sort of like a Nylock nut and holds the parts together better. But threading the screw in the first place can be a test of endurance for your fingertips, particularly when all you have to grip onto is the thin metal handle of an Allen wrench. The task also demands steely resolve, because restarting runs the risk of cross-threading the part. Being cognizant of the parts that need to be threaded is really all that's necessary, as long as you are prepared to apply the necessary pressure to begin with. Some parts like the U

THE HEART OF THE ROVER.

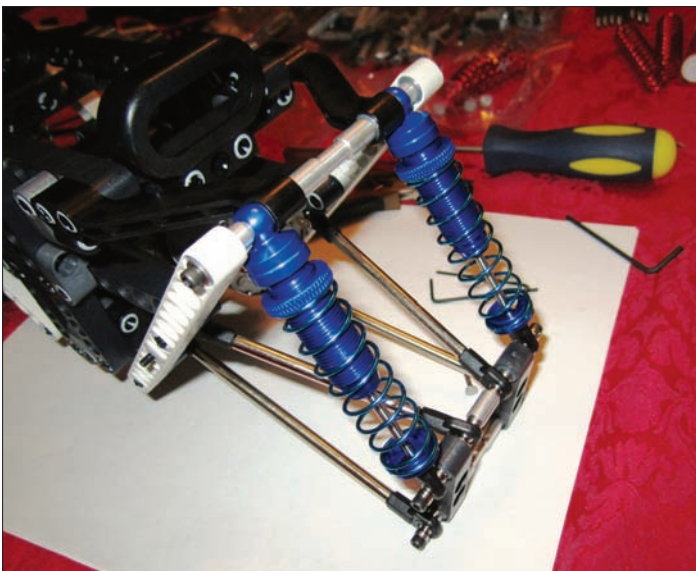




STEP-BY-STEP PROGRESS.



ASSEMBLING THE DIFFERENTIAL.



COOL SHOCKS!

brackets for the drive shafts are even being redesigned to make the task of threading the screws easier.

Speaking of the U brackets (or yokes, to use the term of the instruction manual), that brings us to the most devilish part of the kit. The instruction manual and video on the website indicate that installing the ball joints into the U brackets should be an easy procedure; one that simply requires a minor application of force using the shaft of a screwdriver. So simple that it could be done with one hand. This, however, was not the case. Absent any modification, superhuman force was required to fit the ball joints into the U bracket. We're pretty sure the screwdriver would have broken before the stubborn plastic yielded to the ball joint. We were surprised by the resistance, especially given the design of the U brackets. A shallow channel is visible that appears to gently lead the nibs on the ball joint into its proper resting place. The shallow channel, however, is not enough to compensate for the thick, rigid plastic that makes up the U bracket.

Forced to get creative, we tracked down a small taper file to deepen the channel. Despite some initial doubts of the efficacy of the hack, after a bit of filing the ball joints did eventually submit to pressure from the screwdriver. It was still not an easy task, but it was most definitely physically possible.

Sunshine on the Skyline

With the drive shafts assembled, we were confident that the rest of the construction would be comparatively easy. Our hopes were realized as the wheel assemblies attached to the rest of the frame, and the kit began looking like a real rover. After test-fitting the solar panel, all we had to do was install the electronics.

The instruction manual provides a helpful diagram for wiring up the robot which is a refreshingly straightforward affair. The electronic components include a small speed controller, the battery pack, the receiver, the on/off switch, the wires to the motor, and the solar panel converter. The wires for the motor are outfitted with sockets, so no soldering is required. What is required, however, is a bit of creativity while placing the electronic nervous system into the robot.

The instruction manual tells you how to build a killer drive base, but it provides no suggestions or attachment points for the electronics. Perhaps that is a bit ungenerous – the kit includes some double-sided tape and zip ties, and instructs the user to have at it, and the frame does include a handy casing for the battery. The double-sided tape is actually super helpful, and even though the amount seems small it is more than enough to stick the speed controller, receiver, and on/off switch to the frame.

The rover was finally completed. Given the difficulties with the initial assembly, one might think that the 3-in-1 nature of the kit might be a cause for concern rather than celebration. The most difficult aspects of assembly, however, are the drive shafts, and those only need to be

put together once. Other than that, the kit can be easily disassembled with no more than the MINDS-i tool, a Phillips screwdriver (one is supplied with the kit), and a few Allen wrenches. The MINDS-i tool in particular makes disassembly of the frame rather rapid, and the quick action of pulling out the connector cores is enough to make you feel like a pneumatic tool wielding member of a speedy pit crew.

The kit also comes with a charger for the battery so that users won't be left in the lurch on a cloudy day. With a fully charged battery, we were ready to test the rover and see if the big wheels and shocks could handle all of the terrain that we imagined it could. We were not disappointed. No matter what we placed in its way – whether it was feet or casebooks – the rover always effortlessly bounced over every obstacle.

Dependence Day

The solar charge controller converts the voltage and current from the 13 watt solar panel into something suitable for charging the 7.2V rechargeable battery pack. The controller is easy to wire up because all you have to do is connect one end to the solar panel and one end to the battery back. To prevent any disastrous wiring mix-up, one end uses pins and the other uses a socket. The much thicker gauge wire on one end is also an easy way to tell which side plugs into the solar panel.

We were delighted by the ease of implementing the super cool solar panel but we noticed that because there was only one hookup to the battery and no type of splitter, the battery could only be charged when it was not actually hooked up to the rest of the robot. A way to take advantage of the size of the Lunar Rover while making use of the solar panel would be to give the rover something to charge while roving around. Even though the rover was an appropriate size for a nurturing mothership, we still needed something fairly compact to be carried around. The challenge was to find something small that could be charged by the hefty solar panel – ideally we wanted to find something with a 7.2V rechargeable battery pack just like the rover itself. It just so happened that our trusty VEX kit also used a 7.2V rechargeable battery pack, and we were capable of making a pint-sized robot out of the VEX parts.

We also thought that this was a nice opportunity for the inevitable comparisons drawn between different robotics kits. Putting together the small VEX robot was a much quicker exercise than the assembly of the rover. This was likely in part due to familiarity, but also by the inherent ease of using classic screws and lock nuts. That ease of assembly had a price of course, because throughout our



THE HARD EARNED DIFFERENTIAL.

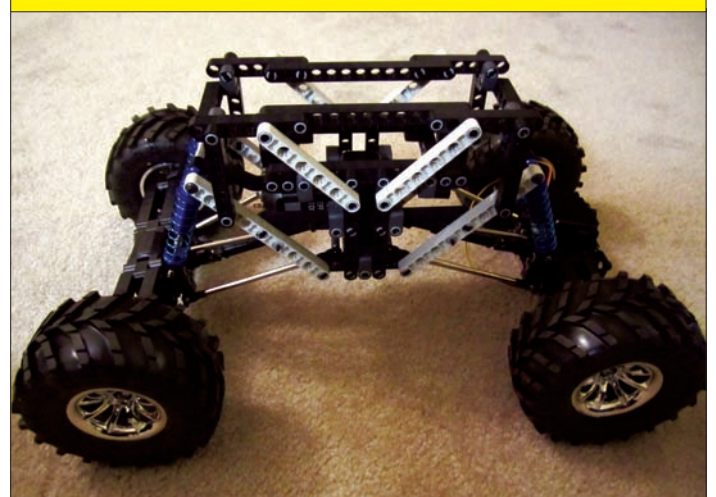


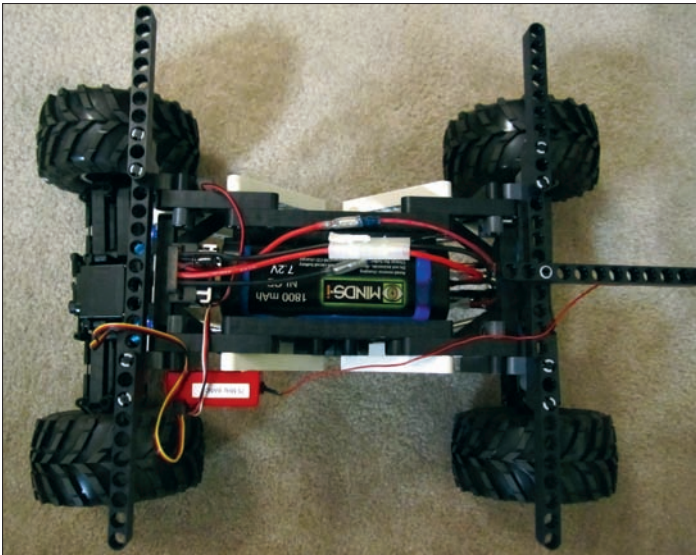
THE OBSTINATE U BRACKETS.

testing of the VEX robot we had to periodically tighten the screws. Despite testing the rover over a variety of obstacles, the MINDS-i bot needed no additional tightening.

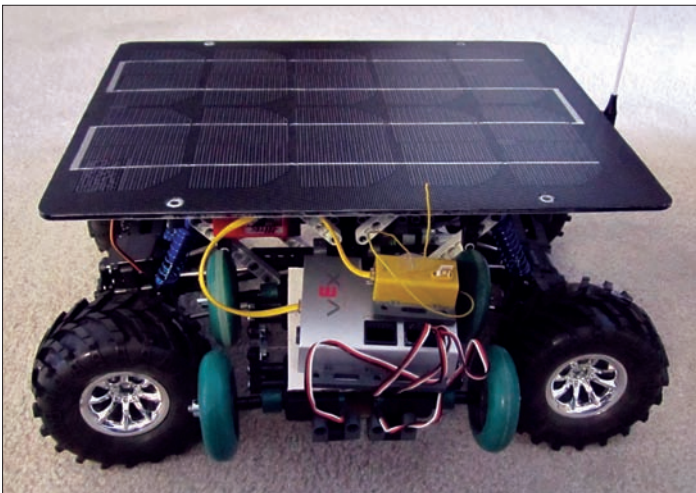
Perhaps the distinction was exaggerated by our goal of creating a tiny robot with the VEX kit, but the scale of the kits is one of the most notable differences. Correlated to the scale of the kits is the power used to move them. The VEX robot is great for small scale tasks – like the object retrieval of Science Olympiads of yore – but even a major gear ratio will give the VEX servos only limited oomph. Also, the specialized VEX parts make implementation of non-kit motors an option, but one that requires extra hacking. The Lunar Rover, on the other hand, is specially

THE COMPLETED DRIVING BASE.





WIRING UP THE ROVER.



BEING A GOOD MOTHERSHIP.



CHARGING THE VEX ROBOT.

designed to be compatible with non-kit motors.

We had all the parts we needed to turn our Lunar Rover into a Lunar Mothership. A simple shelf was all that was needed to hold our VEX robot which was small enough to fit perfectly between the wheels of the rover. Despite its small size, the VEX robot still had some weight to it, so we needed a counterbalance on the other side of the rover. After numerous attempts including coasters, water bottles, and a clock, we found the ballast with the ideal size and weight: a glass of Starbucks vanilla frappuccino. With our tiny VEX robot nestled away, we had a robot within a robot. It was a good thing that we didn't have to go deeper, because a robot within a robot within a robot would have been a bit much.

Even carrying around a VEX robot and a frappuccino, the rover was able to negotiate obstacles with ease and didn't seem to lose any speed. Such success indicated the rover would be more than able to carry around a variety of mechanisms, made both from kit and non-kit parts. One of the limitations on expandability that many kits face is the lack of an intuitive way to include non-kit parts in a project. Most kits use their own kind of fasteners, and the MINDS-i system is no exception with its two-part connectors. And while these plastic connectors might be a great and easy way to put the kit parts together, most non-kit parts rely on far more traditional nuts and screws which can be difficult to mate to the specialized plastic frame bits.

The MINDS-i kit offers an elegant solution to this problem by including screw adapters that fit into the frame mounting holes. The screw adapters come in two halves, with one half being a through hole and the other featuring a narrower bore that 4-40 screws can thread into. The screw adapters are used in the kit as a way to attach the shocks, and we also see them as an easy way to add non-kit parts to the rover.

Opening Up Your Mind's Eye

We think the folks at MINDS-i are on track with their goal of creating a system more durable, powerful, and interchangeable than many current offerings. On the note of durability, many kits that are easy to put together are also easy to take apart – by the user and by things like terrain and simple usage. While the Lunar Rover took some effort and force to assemble, the result was something that wouldn't fall apart when you didn't want it to. Also, the most difficult parts to put together were the ones that you wouldn't have to disassemble again, like the drive shafts.

On the note of power, the single DC motor in the Lunar Rover gives the robot impressive speed and more than enough torque to clamber over all sorts of obstacles. Perhaps the most exciting aspect of the kit, however, is the interchangeability. The MINDS-i system is designed to work with virtually any hobby motor, and thus allows users to power their rovers (and any additional mechanisms) with even beefier motors. This was quite appealing to us in particular, because over the years we have found other

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BUILD ANYTHING

Ignite your creativity and imagination with the all new MINDS-i construction system. Finally, a rugged quick-lock system that empowers you to envision, build, and re-create anything that you can imagine with your own "mind's eye".



Patents US 7,517,270; US 7,410,225 B1; US 7,736,211; US 7,841,923; International Patents Pending.

DO ANYTHING

Utilize PCS Robotics controllers, sensors, and software to bring MINDS-i to life. Use PCS curriculum in the classroom to elevate your student's interest in science, technology, engineering and math!

pcsedu.com/servo

imagine it



PRO-LINE
RACING FABRICATIONS

build it



crawl it

re-design it



program it



race it



robotic design systems to be well suited to a variety of robotics competitions with one major caveat – the kit motors for many of these kits are not powerful enough to handle arduous tasks. Also, the receptiveness of the MINDS-i Team to customer feedback and the actual implementation of that feedback in design changes is the hallmark of a great robotics system. The devilish U brackets and a few other plastic parts have been redesigned in response to customer feedback. The two major issues identified above – the difficulty of threading some of the parts yourself and the challenge of installing the ball joints in the U brackets – have been addressed by new molds for some parts. With such a responsive team behind the MINDS-i system, we can envision kits like the Lunar Rover becoming favorites in competitions and in the classroom.

Some purist roboticists may still not be impressed. They demand to see a platform that is more than a nice construction system, but one that can be programmed and outfitted with sensors. The MINDS-i folks have planned for just such an audience, because they've partnered with PCS Edventures to create a comprehensive robotics design system. The Lunar Rover kit and others are designed to be

compatible with the PCS Brain microcontroller and sensor pack. Far more than just a cool way to add some autonomy to the MINDS-i kit, PCS Edventures has designed curriculum meant to help teach robotics in the classroom. We'll get the chance ourselves to test out the PCS Brain in the Lunar Rover in an upcoming article, and we hope that you join us for that "edventure!" **SV**

LUNAR ROVING!



RECOMMENDED WEBSITES

www.mymindsi.com
pcsedu.com