

QUIZ: WHAT'S YOUR DIY IQ? P. 64

POPULARMECHANICS.COM | MARCH 2010



Popular Mechanics

SCIENCE OF
THE OLYMPICS

Science Technology Automotive Outdoors Home

AIR STRIKE 2025

THE RADICAL PLAN
TO REINVENT THE
AIR FORCE

“A ROBOT IS MY
WINGMAN”

Malestrom

SUPER TUGBOATS

LONG-TERM TEST CARS

KAYAK FISHING

DIY

SMARTER VINYL BASEBOARD
CAR STORAGE FOR THE LONG HAUL
SILENCING YOUR PC

WE TEST TOP LAWNMOWERS

AN F-35A LIGHTNING II WITH
A SWARM OF NEXT-GEN
UNMANNED AIRPLANES



Popular Mechanics

Mar.

PM FEATURES
VOLUME 187 NO. 3

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Over the Horizon

When the Air Force recently mapped out a game plan to 2047, the report contained a big surprise: fewer pilots and more UAVs acting on their own. Will the airman-centric service accept a future with few cockpits?

BY JOE PAPPALARDO

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Super Tugs

As ships get bigger, towing companies build more powerful and agile tugboats to guide the behemoths in and out of port. PM rides on the 6500-hp *Edward J. Moran*, tasked with escorting a liquefied-natural-gas tanker that some call a giant floating bomb.

BY CARL HOFFMAN

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Test Your DIY IQ

From paint chemistry to attic insulation, the PM do-it-yourself quiz separates the expert from the amateur. Where do you stand?

BY HARRY SAWYERS

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Olympic Science

Whether athletes at the 2010 Winter Games in Vancouver compete on snow or ice, they train hard and invest in state-of-the-art equipment to harness complex physics—and win the gold.

BY DAVIN COBURN

86

Small Boat, Big Fish

New designs make fishing kayaks stealthier and far more stable than their traditional counterparts, allowing anglers to go where no motorboat can and reel in huge fish without risking an unwanted dip.

BY T. EDWARD NICKENS

PM's DIY IQ quiz (page 64) illuminates the brightest bulbs—and the dim ones. The test's biggest answer? Whether or not you know what you're doing.

ON THE COVER

A report released by the U.S. Air Force reveals that the agency is considering replacing pilots with autonomous robots like the multirole, stealthy UAVs shown on the cover. These aircraft could fly in formations with piloted warplanes such as the F-35 Lightning II. Illustration by Mike Hill.

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WHAT THEY'RE DOING



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A board member of the U.S. Civilian Research and Development Foundation, a group that funded former Soviet weapons designers doing civilian research and production in the mid-'90s, Wulf has been working to foster peaceful international scientific collaboration in additional locales: Kazakhstan, Belarus and, most recently, areas in the Middle East.



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PM LETTERS

like me, who automatically assume that green equals crappy and overpriced.

MICHAEL LORTON
SAN FRANCISCO, CA

Saturday Mechanic

I recently took my Suzuki SX4 to the dealership to have the standard lube, oil and filter service. The car has about 16,000 miles on it. The mechanic called and told me the throttle also needed to be cleaned. I wasn't familiar with that service, so I did an Internet search on "Does a throttle have to be cleaned on a car?" The first article to pop up was written by Mike Allen and published in the May 2001 issue of *POPULAR MECHANICS*. It clearly explained the complete procedure and when it was appropriate to have it done. I will certainly keep a lookout for Mike Allen's articles in the future. He saved me over a hundred dollars!

LORRE BRADBURY
PHILADELPHIA, PA

→ CALLING ALL HOMETOWN HEROES

Do you know someone who has contributed in a positive way to your community? Maybe a handyman who volunteered to rebuild a storm-damaged school, or a tech-savvy citizen who rigged up a Wi-Fi network for the local library. *POPULAR MECHANICS* is currently accepting nominations for our 2010 Hometown Hero Awards. If you know someone worthy of recognition, he or she could be honored in the magazine. For more details and to submit your nomination, visit popularmechanics.com/hometownhero.

Digital Species

I enjoyed your article on the technology behind the movie *Avatar* ("View From the Brink," Jan. '10), especially how director James Cameron developed new cameras and software that combine live action and animation to create the digital version of the movie's characters. This blend of digital and human elements makes one ponder the relationship between the actors and the characters. Since the final animation is so intimately tied to the actor's portrayal of the character, yet so heavily dependent upon the director's digital manipulation, do movie viewers still witness the artist's pure craft of acting? As this technique improves, which I think is bound to happen, the distinction between digital and traditional film characters is going to be increasingly blurred—and our concept of reality will be chipped away yet again by new technology!

PAT TRIBBLE
SUMMIT POINT, WV

I applaud James Cameron for his patience during the 10-year



ISSUE

01/10

x

Readers responded to a look at 3D movie technology, an abusive lab test of trash bags and tips from our resident Saturday Mechanic.

process of developing the innovative technology to create his film *Avatar*. The imagination and desires of this artist have pushed the bounds of possibility. Hopefully, the developments for the film will not be limited to the realm of entertainment and will some day spread into other, more practical applications.

DAVE LEE
SANTA CRUZ, CA

Tough and Green

I was a bit surprised by the results of your January "Abusive Lab Test" on three brands of contractor trash bags: EconoGreen, Hefty and Grip-Rite. Of the three tests—weight capacity, abrasion resistance and puncture resistance—the EconoGreen bag prevailed in two (Grip-Rite won the abrasion test). If the manufacturer has any brains, it will market the bags with a name such as TuffStuff for people

what
do you
think?

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Do-It-Yourself



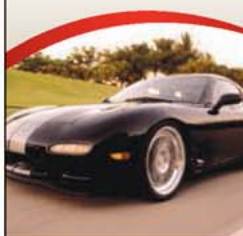
PM OWNS SATURDAY PM provides everything but the materials and tools to accomplish your weekend projects. We have step-by-step directions for hundreds of home projects like hanging TVs, caulking bathrooms, building Adirondack chairs, erecting pergolas and installing drywall; guides for kitchen DIYers looking to brew beer or fry turkeys; and instructions for dozens of fun projects for the whole family, such as soda-pop bottle rockets, DIY gifts and other tips.

TOOL TESTS From straightforward comparison tests of saws and oscillating hand tools to a look at next-gen string trimmers powered by propane, gas and electricity, PM editors don't just list the latest products from tool manufacturers—we rigorously test them to see if they pass muster and live up to their promises.

HOME NEWS Whether it's the latest warnings about Chinese drywall, a look at the full impact of the new lead regulations or the truth about the Cash for Caulkers (or cash for appliances) program, PM cuts through the spin and brings timely analysis of the policies and problems that affect homeowners.

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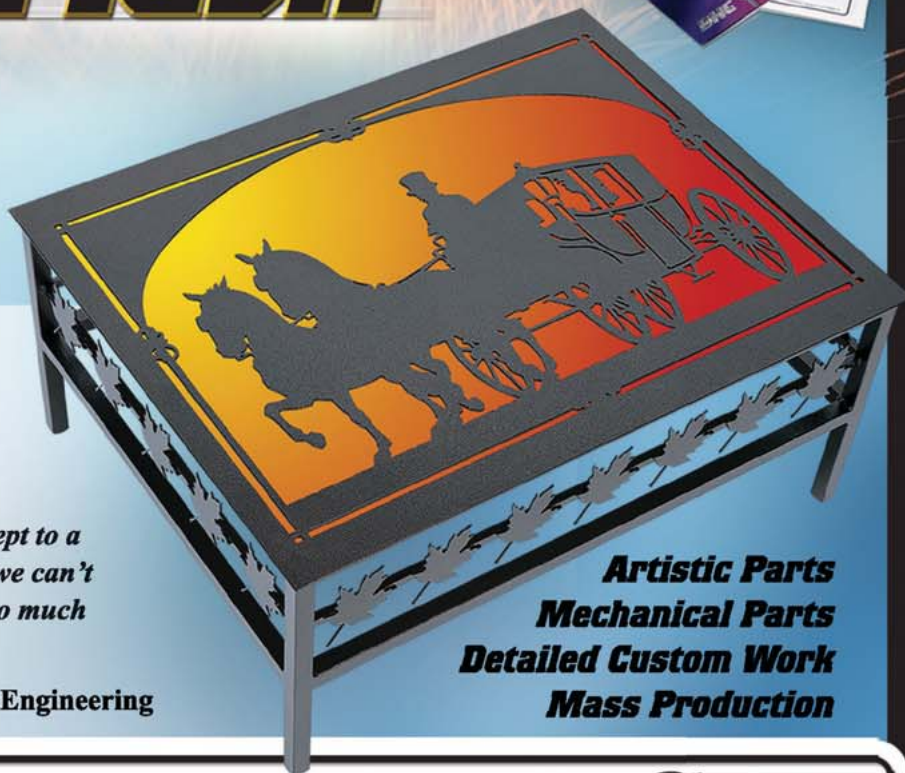


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Tech Watch

36.7%

percentage of domains' tainted websites

32.2%

23.4%

the worst domains

(.cm)

CAMEROON

The domain has become popular for scam sites that rely on misdirects—e.g., typos that leave the “o” from “.com”—to make money.

(.com)

COMMERCIAL

The study weighs the riskiness of a domain according to its number of sites. Its authors found malware on 6 percent of the 15.4 million .com sites analyzed,

and adjusted the risk ratio to reflect the large number of infected sites.

(.cn)

PEOPLE'S REPUBLIC OF CHINA

most improved domain

(.hk)

HONG KONG

Led the list of risky domains in 2008, but after the police cracked down on Internet abuse, .hk dropped to 34th place in 2009's tally.

(.jp)

JAPAN

0.1%

(.edu)

EDUCATIONAL

0.1%

(.gov)

GOVERNMENTAL

0.0%

1.1%

the best domains

Risks of Clicks

Not all URLs are equal when it comes to passing along unwanted malware. Internet security company McAfee mapped the most dangerous domains in a recent report. Here's a snapshot of the best and worst. *BY JOE PAPPALARDO*

SEATBELTS WITH A SURPRISE

→ Michigan-based Key Safety Systems has unveiled the world's first inflatable car seatbelt, which enhances a traditional three-point shoulder belt with an airbag. When the vehicle detects a collision, the belt inflates with cold gas to five times its original width. The first belts will appear in Ford Explorers going into production this year.



TANGLING WITH PIRATES

↑ Commercial shipping vessels desperate for ways to defend themselves from pirate attacks off the coast of Somalia could soon have a nonlethal way to fight back. The Buccaneer, built by Wales-based BCB International, is a deck-mounted weapon that allows besieged sailors to disable attacking ships. The compressed-air device launches a coiled rope over a quarter-mile. A parachute attached to one end of the rope

controls the descent so that the rope lies across the surface of the water, entangling the propeller shaft of the threatening vessel. Many nations bar commercial ships from being armed, and adding weapons often increases insurance rates because of the risk of accidents. The Buccaneer is an attractive alternative to firearms.

— ALEX HUTCHINSON

\$1.2 Million in Milk Money

WHY IS MISSY THE MOST
EXPENSIVE DAIRY COW
IN THE WORLD?

BY ERIN SCOTTBERG

When a trio of investors bought Missy the cow for a record-setting \$1.2 million at an auction at Toronto's Royal Agricultural Winter Fair, outsiders gained a glimpse into the arcane world of elite livestock breeding. Whether it's the width of her hips or the protein content of her milk, Missy excels. "She's got the total package," says Michael Hutjens, a dairy specialist at the University of Illinois at Urbana-Champaign. Missy's value is enhanced by the likelihood that she will pass those excellent genes on to generations of offspring. Any male calves will be especially valuable for their sperm. Within the next seven years, dairy farmers expect that there could be 60 to 75 cattle carrying Missy's genes.

1. UDDER

The preferred width is at least 8 inches. A cow with strong ligaments supporting the udder is less likely to get a mammary gland infection because its udder is farther from the ground.

2. TEATS

Dairy farmers prefer that the teats of dairy cows fit into milking machines—they should be perpendicular to the floor and have a cylindrical shape. Missy's milk makes more cheese per volume because it's so protein-rich.

3. LEGS

The width between Missy's rear legs is important because it allows room for the udder; the wide space between her front legs indicates a large chest cavity, a sign of a healthy heart.

1. UDDER

2. TEATS

3. LEGS

Solo Act

NEW FORENSIC ANALYSIS SHOOTS A HOLE IN A KENNEDY ASSASSINATION CONSPIRACY THEORY. BY ALEX HUTCHINSON



Digital forensic tools have added to the evidence that Lee Harvey Oswald was a lone gunman rather than part of a conspiracy to kill President John F. Kennedy. Hany Farid, director of the Neukom Institute for Computational Science at Dartmouth College, analyzed a famous photo of Oswald that some say must have been doctored, because the shadows under Oswald's nose and behind his body appear to be caused by different light sources. However, Farid found no sign of tampering when he measured for inconsistencies in the image's underlying pixels.

He also created a 3D image of Oswald that demonstrated that both shadows could have been made by the sun at the time Oswald's wife took the photo. Farid says that the image would be hard to fake today, and likely impossible using 1963 technology.

Designed to Deliver

THE NAVY'S NEWEST WARSHIP IS BUILT FOR FERRYING MARINES TO COMBAT ZONES IN SAFETY AND, YES, STYLE. BY JOE PAPPALARDO

→ The **USS New York**, currently in pre-deployment sea trials, is the Navy's newest Landing Platform Dock ship, designed to deliver the Marine Corps to wherever it's needed. The 700 Marines on the ship travel ready for combat, and that means amphibious hovercraft, attack helicopters, tanks and tilt-rotor MV-22 Ospreys come along for the ride. The *New York* has the most famous hull in the world—the Navy integrated 7.5 tons of steel from the fallen World Trade Center towers into the bow. But that is not the only interesting detail of the vessel's design.



USER-FRIENDLY LAYOUT

✱ The **USS New York's passageways** are spacious enough to keep equipment mounted in the hallway from snagging Marines or sailors as they pass by. The long, straight passageways—or as sailors say, “p-ways”—take into account who uses them. For example, the ladders between Marines’ berths and their landing craft are wider than any others on board, to accommodate the Marines’ bulging backpacks.



STEALTH CRANE

✱ The crew uses this 22,000-pound **knuckle boom crane** to hoist boats into and out of the water and to move cargo to and from the ship. Enemy radar could get a string signal from the crane, so it's housed in radar-absorbent material. A door underneath the arm swings open to deploy the crane's hoist block. Vehicles can drive down ramps to the lowest decks where the landing craft launch.



LOW PROFILE

✱ The *New York's* eye-catching shape, with **two smooth, cone-shaped masts** jutting from the deck, makes it very difficult for enemy radar to spot the ship. Every visible surface is faceted at 10-degree angles to prevent radar waves from bouncing back and returning a clean signal. The dual masts are enclosed in a composite material that allows radio and radar transmissions to pass through.

Checking Your Eye-Ds

THE FEDS GIVE A SEAL OF APPROVAL FOR IRIS SCANS ON FUTURE ID CARDS.

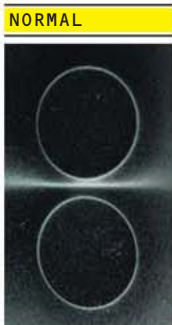


As government agencies and corporations tighten security, new technology is promising to let them incorporate eye-scan data into identification cards. At a checkpoint, an eye scanner would match the subject's iris to an image stored on the card—making it easy to spot a fake ID or an impostor. Iris images are about 30 kilobytes in size, but the files must be condensed to 3 KB to be used on a card, and that compression degrades the image's resolution. In studies funded by the Department of Homeland Security, the National Institute of Standards and Technology identified compression technologies that could be used in new passports and driver's licenses—and perhaps even national ID cards. — A.H.

Changing Faces of Magnets

A STARTUP COMPANY IN ALABAMA CUSTOMIZES THE POLES OF MAGNETS, OPENING NEW WORLDS OF POSSIBLE USES.
BY JOE PAPPALARDO

HOW
IT
WORKS



The blank face of typical magnets, shown here under metal-infused magnetic-field paper, can be imprinted with multiple poles. Fullerton uses a powerful electro-magnetic print head to trace new patterns onto magnets. He also developed a method to make more precise patterns: He heats magnetic material to the point that it loses its magnetism, then reprograms the material by bringing it into contact with a magnetic stamp. The stamp instills new field patterns, and when the material cools, the multipole pattern remains.

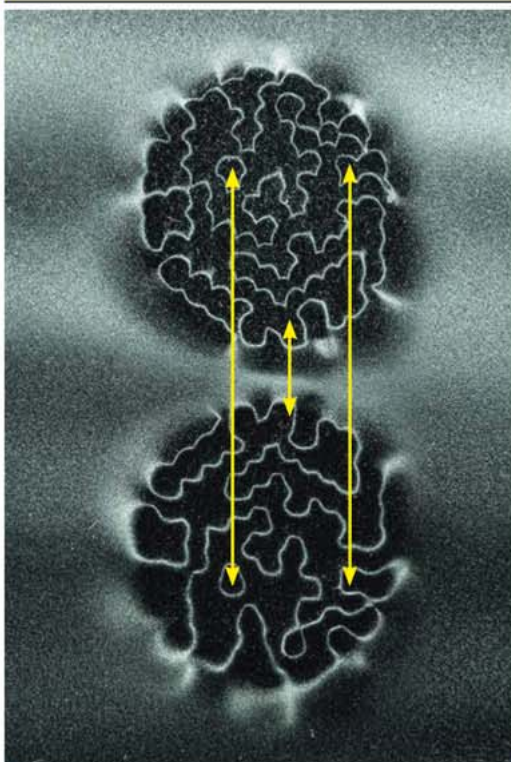
→ **Larry Fullerton** is a former NASA engineer with experience developing advanced radar systems and ultra-wide-band communications technology for the military. But when he tried to assemble toys for his grandchildren, he found himself stumped. "What if these could self-assemble?" he asked. "I knew it would have to be done with magnets." Most magnets used in self-assembly initiate action by using electricity to switch their north and south poles. But Fullerton had an idea: What if he could instill multiple poles, instead of just two, into magnetic material?

Fullerton is now serving as CEO and chief scientist of Alabama-based Correlated Magnetics Research, which late last year unveiled magnetic devices unlike any others. When the correlated patterns on CMR's magnets match—with the opposite charges fitting together like jigsaw puzzle pieces—they attract and clasp. With a slight rotation, the correlation is lost and

the two sides can be easily separated. Imagine a superefficient freezer door that seals at 25 pounds per square inch but can be opened after a turn of the wrist reduces the attractive force to 4 psi.

CMR is looking to license tech to various industries, so these magnets could conceivably turn up almost anywhere, particularly in niche markets such as NASA hardware and military gear. Programmable magnets could be used to seal spaceship hatches, to create friction-free prosthetic ball joints and to make long-lasting gears for engines. In truly foolproof assemblies, smart magnets would ensure that every part links only where it belongs. Experts say the physics makes sense. "It seems to be legitimate engineering," says Bill Butler, the director of the University of Alabama's Center for Materials for Information Technology. "It also seems to be elementary. That said, sometimes the best ideas are the simple ones."

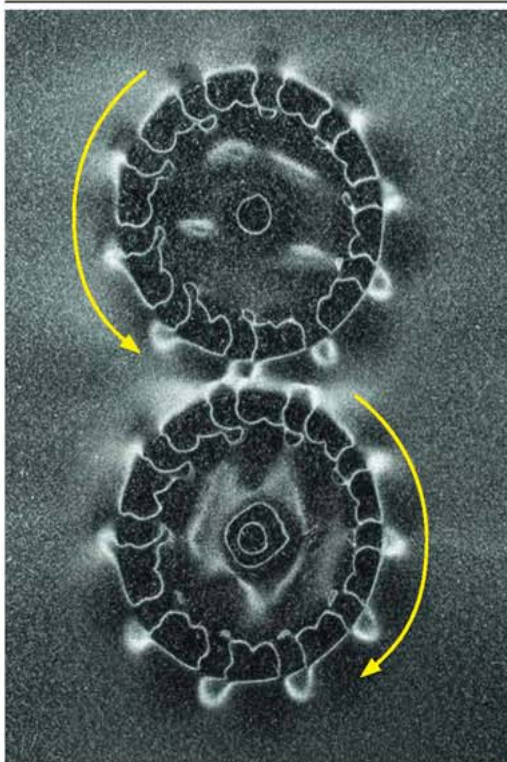
CORRELATED



USE THE FORCE

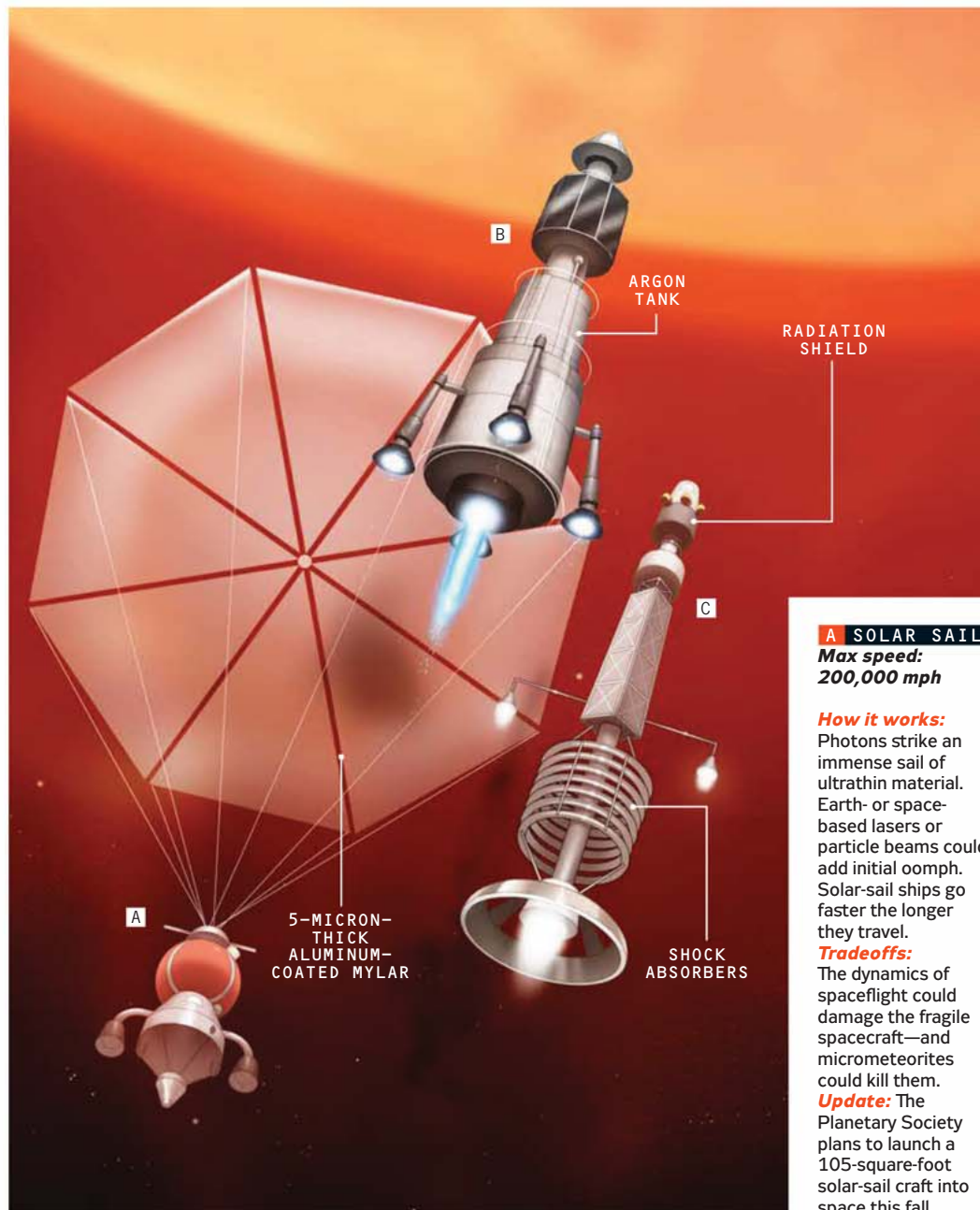
When the patterns align, the magnets stick tightly together. Rotating one magnet reduces the attraction. Placing these magnets in a refrigerator door would form a seal that users could open easily.

GEARS



INVISIBLE GEARS

When one magnetic disc turns, the other corresponds without touching. CMR engineers built a nearly frictionless generator that is run by a wind turbine.



Faster, Lighter Space Engines

INTERPLANETARY TRAVEL MAY AWAIT PROPULSION SYSTEMS LIFTED FROM SCI-FI NOVELS.
BY MARK WOLVERTON

➔ **Chemical combustion engines** are an unbeatable technology for escaping Earth's atmosphere and gravitational pull. In space, however, these rockets are inefficient—they burn through huge quantities of fuel while generating more thrust than necessary. That's why researchers are increasingly turning to nonchemical propulsion systems, which could drastically lighten spacecraft while achieving higher speeds. Some of the ideas being researched, like antimatter engines, depend on established physics but go far

beyond current technology. "Someone's got to think beyond the obvious," says Marc Millis, a propulsion physicist at NASA's Glenn Research Center. "You have enough other people in the world doing the next obvious thing. By reaching beyond that, you can discover the breakthroughs other folks aren't even looking for, and change everything."

B ION

Max speed:
220,000 mph

How it works:

Electrically charged molecules shoot from the engine to propel the ship. A nuclear reactor or solar cells provide the electricity.

Tradeoffs:

Ion engines can't overpower Earth's gravity, but in space they require little fuel.

Update: NASA used an ion engine in its Deep Space 1 mission in 1998. MIT engineers won a 2009 PM Breakthrough Award for a less expensive design with about 10 times the thrust. And an ion engine built by Ad Astra Rocket Company may be tested at the International Space Station in 2013.

A SOLAR SAIL

Max speed:
200,000 mph

How it works:

Photons strike an immense sail of ultrathin material. Earth- or space-based lasers or particle beams could add initial oomph. Solar-sail ships go faster the longer they travel.

Tradeoffs:

The dynamics of spaceflight could damage the fragile spacecraft—and micrometeorites could kill them.

Update: The Planetary Society plans to launch a 105-square-foot solar-sail craft into space this fall.

C ANTIMATTER

Max speed:
270,000 mph

How it works: An engine harnesses the enormous energy released when matter and antimatter come into contact.

Tradeoffs: Creating enough antimatter in particle accelerators is currently impossible. The engine would also have a damaging kick and produce a lot of radiation.

Update: Penn State researchers have conceived of an engine to drive a spacecraft with shock absorbers tough enough to survive the collisions of protons and antiprotons.

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shape-shifting special effects—he won an Oscar for *An American Werewolf in London* and turned Michael Jackson into a murderous beast in his *Thriller* music video. Baker drew from his own experi-

ence, physiognomy sketches and the 1941 movie's design to turn actor Benicio Del Toro into a cursed creature. "One thing I found odd about [1940s actor] Lon Chaney Jr.'s Wolfman is that he's got human ears," Baker says. "It seems like you'd want to make them pointy. That was one of the first changes I made."

Once the design was finalized, Baker took a mold, or lifecast, of Del Toro's head. Next, the artist sculpted canine features on the lifecast.

From those sculptures

he created fiberglass molds, which he filled with foam latex. The molds were cured for 8 hours to create the appliances that Baker adhered to Del Toro's face: First, a cowl with the canine ears, then a face piece with a snout. The last step was laying strands of yak hair by hand. Despite his long legacy of creating cinematic werewolves, Baker feels a special affinity for this remake. "The classic Universal horror films are why I do what I do for a living," he says. "I'm glad to know that in this day and age, makeup is still considered an option."

Not Your Grandpa's Wolfman

MAKEUP ARTIST RICK BAKER USES OLD-SCHOOL TECHNIQUES TO TURN ACTOR BENICIO DEL TORO INTO A CURSED CREATURE. BY ERIN MCCARTHY

→ These days, most filmmakers use computer graphics to create mythical beasts. But for *The Wolfman*, an update of the 1941 Universal horror classic, director Joe Johnston wanted to take a more traditional approach. "Because you can do anything with CG, I think a lot of filmmakers sometimes do things that go beyond what is believable to an audience," he says.

Johnston used CG for transformation scenes but turned to legendary makeup artist Rick Baker to bring the new Wolfman to life. Baker is the king of

HISTORY
OF
WEREWOLVES
IN THE
MOVIES



1935

Werewolf of London

→ The transformation of actor Henry Hull occurred in two cuts: As the actor walked behind pillars, he emerged in stages of werewolf makeup.

1981

The Wolf Man

→ Actor Lon Chaney Jr. transforms in a dissolve. Filmmakers traced Chaney's outline on glass panes affixed to three cameras and used the outlines to reposition the actor for another shot after he returned from makeup.

2003

An American Werewolf in London

→ To pull off actor David Naughton's transformation, makeup artist Rick Baker built prop hands and feet. A mechanism inside the props distorted them into different shapes.

2009

New Moon

→ VFX artists devised a computer program that would allow a 1200-pound wolf to pop out of a 160-pound man. Filmmakers scanned 3D models of the actors, then put those models in the system. The wolves are entirely digital.

2010

The Wolfman

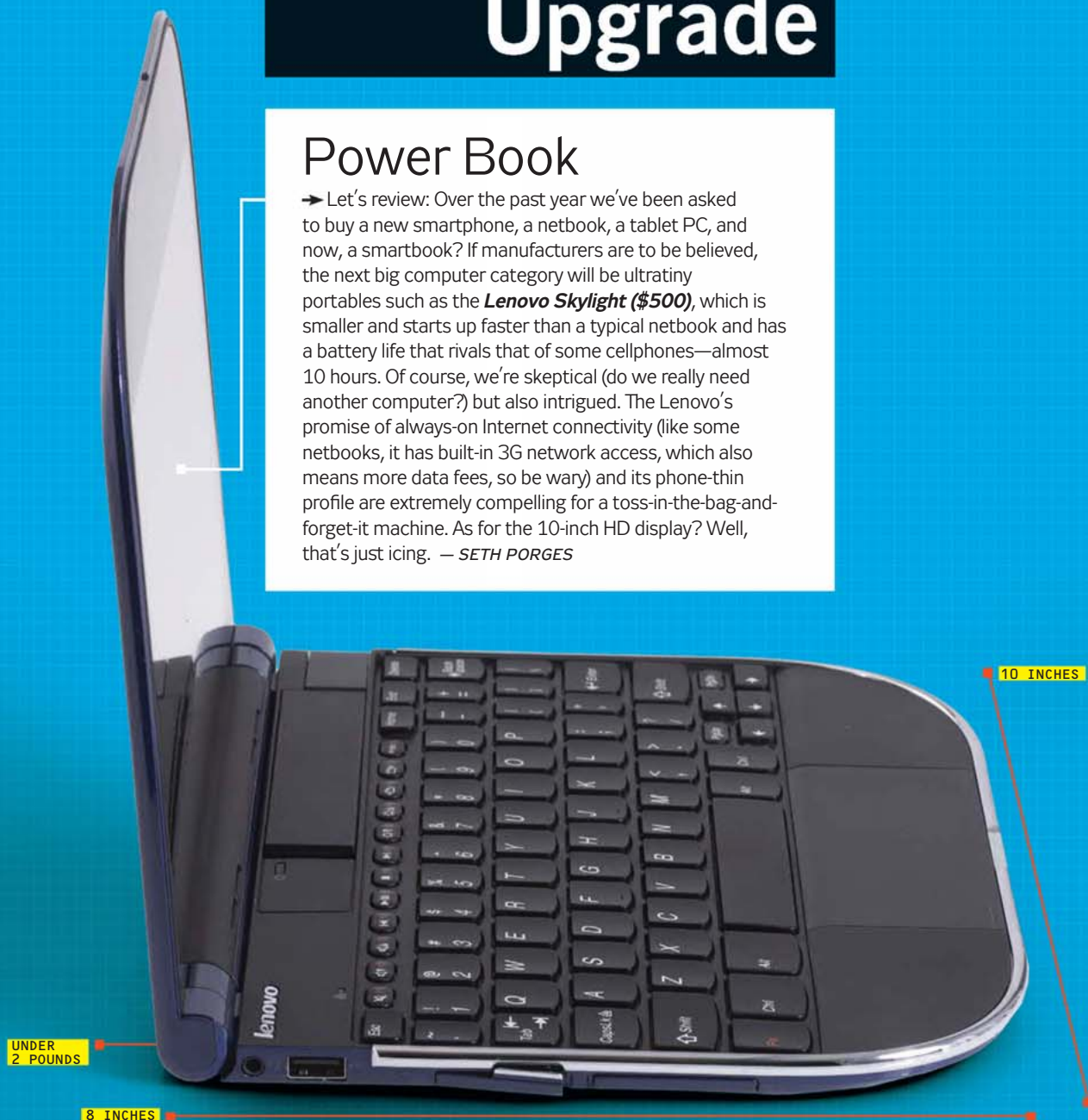
→ Though the final wolfman is a human in wolf makeup, director Joe Johnston used CG for the transformation. "It's an issue of flexibility," he says. "If you use CG, you can change your mind."



Upgrade

Power Book

→ Let's review: Over the past year we've been asked to buy a new smartphone, a netbook, a tablet PC, and now, a smartbook? If manufacturers are to be believed, the next big computer category will be ultratingy portables such as the **Lenovo Skylight (\$500)**, which is smaller and starts up faster than a typical netbook and has a battery life that rivals that of some cellphones—almost 10 hours. Of course, we're skeptical (do we really need another computer?) but also intrigued. The Lenovo's promise of always-on Internet connectivity (like some netbooks, it has built-in 3G network access, which also means more data fees, so be wary) and its phone-thin profile are extremely compelling for a toss-in-the-bag-and-forget-it machine. As for the 10-inch HD display? Well, that's just icing. — **SETH PORGES**





Tough Shot

→ We're big fans of ruggedized cameras, which can be bumped, dropped or dunked without worry. But the added padding usually comes with a size premium. With a pocket-friendly profile of just 0.78 inches in thickness, the 12-megapixel, 3x-optical-zooming **Casio EX-G1 Camera (\$300)**—which is designed to stay submerged under 10 feet of water or fall from a height of 7 feet—is the slimmest ruggedized shooter we've ever seen.



Hatchet Job

→ When a standard tool's narrow functionality just fails to satisfy, reach for the **Brook & Hunter Mo-Tool Axe (\$40)**, a multitool with a versatility bordering on insanity. Its hammer/hatchet head splays open to reveal plier jaws

and a wire cutter, and a Swiss Army-style handle fans out into multiple cutting, sawing, driving and bottle-opening blades. This gizmo may not replace an entire toolbox, but it certainly scores points for convenience and ingenuity.

Shocking Sequel

→ The original *BioShock* was one of 2007's biggest video-game surprises—a steampunk-inspired meditation on free will that took players through an elaborately detailed underwater city. What really set the

game apart: In contrast to the black-and-white nature of most games, *BioShock* gave players moral dilemmas for which there were no clear-cut solutions. The result was as much a breakthrough in storytelling and scriptwriting as gameplay. For *BioShock 2* (\$60), players return to this dystopia under the sea, with new weapons, powers, bad guys and moral quandaries. And while it will all be familiar to anybody who has played the original, fans of that too-short game will eat it up. After all, if it ain't broke, why fix it?





Great Plane

→ Stanley's classic bench planes debuted over 100 years ago, and many of the originals are still around and in

fine working order. Now that's an argument for investing in a quality tool. The recently reissued ***Stanley No. 4 Smoothing Bench Plane*** (\$140)

is a pricey choice, but amortized over a century, it starts to look like a good value. Classy details include the 1/8-inch A2 steel iron and solid-cherry handles.



Rorschach Tool

→ Looking like a cross between a painter's five-in-one tool and a ninja throwing star, the **Gerber Shard** (\$8) packs a pry bar, a wire stripper, a bottle opener and three screwdrivers onto a single key-chain-friendly chunk of steel.

Light Reserve

→ Leave most batteries in a drawer for too long, and they'll lose their charge. Not the backup battery in the **mPower Emergency Illuminator LED Flashlight** (\$250). The manufacturer claims it can sit untouched for 20 years and still start up. The secret: Its lithium-based chemical cocktail doesn't actually mix until you call it into action for the first time. The device also comes with a USB plug for siphoning off power to gadgets during blackouts or emergencies. So it gets high marks for utility. For budget-conscious design? Not so much.



Abusive Lab Test

STAINLESS-STEEL TRAVEL MUGS

→ You drink coffee from a paper cup or ceramic mug at your own risk—spill your drink while commuting, and the results can be messy, if not devastating. So when it comes to serious spill-proofing and all-day heat retention, stainless-steel travel mugs are the gold standard. We tested three new models to see how well they hold heat and stand up to spills. **BY SETH PORGES**

HEAT RETENTION

We filled each mug with boiling 212-degree water and then measured the temperature after an hour at room temperature.

+ **THERMOS:** If you like your coffee hot, this mug's for you: After an hour, the water was still a scalding 183 F.
OXO: Our water dropped 52 F to 160 F. A third-place showing, but still far better than our foam and paper control cups (which finished at 134 F and 117 F, respectively).
CONTIGO: Second place by a hair: Our thermometer clocked the Contigo at 166 F.
WINNER: Thermos

DURABILITY

To prevent spills, these mugs rely on potentially fragile gaskets and seals. We dropped them from height until they leaked.

+ **THERMOS:** Our hardest mug took eight falls from our lab ceiling's 9.5-foot height before leaking liquid—and even then there were no dents or signs of visible damage.
OXO: After three falls from 9.5 feet, the button-activated seal was permanently broken.
CONTIGO: The weakest entrant's cap became useless after a single 6-foot fall.
WINNER: Thermos

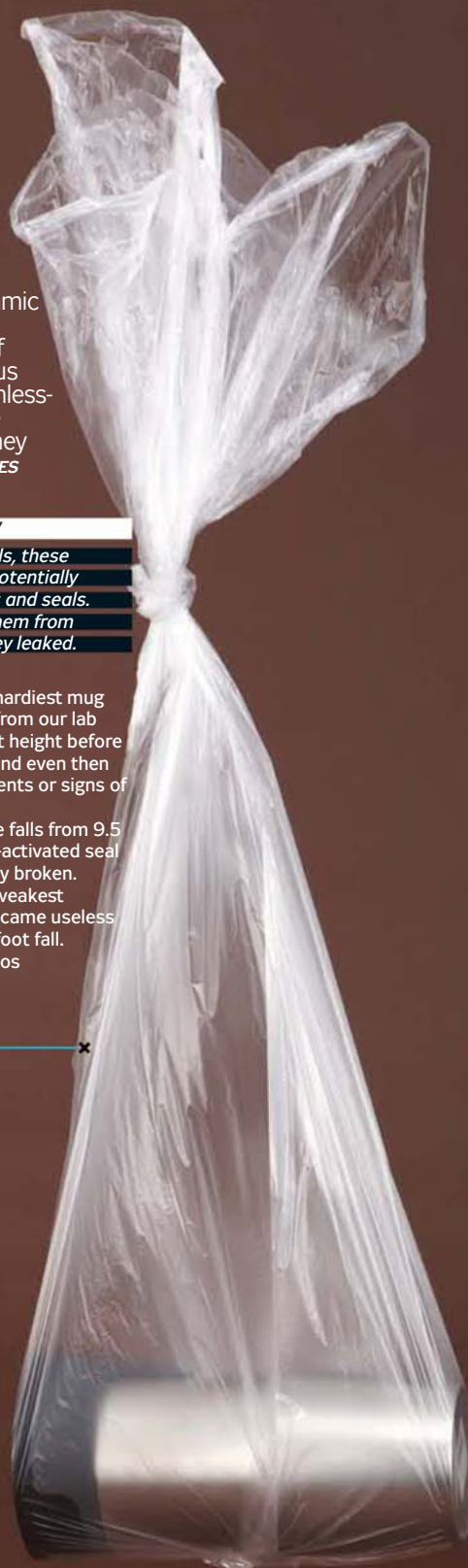
SPILL-PROOFNESS

To simulate real-life spill scenarios, we banged the mugs around in a bag and repeatedly knocked them over a keyboard.

+ **THERMOS:** No amount of bashing could bust the switch-based valve. But when left open, it was prone to tips.
OXO: Its push-button valve held its own—but only if you remembered to lock it.
CONTIGO: The Contigo proved the most spill-proof for a specific reason: Its opt-in valve is open only while you hold down a button. Let go of the mug, and it snaps shut instantly, greatly reducing the odds of a spill.
WINNER: Contigo

BOTTOM LINE

→ Although all three mugs should be able to handle normal use without problems, the Thermos proved the most durable pick and the best choice for people who like their beverages scalding.



the mugs



Thermos Stainless King
(\$25)



Oxo Stainless-Steel Travel Mug
(\$22)



Contigo Autoseal Stainless-Steel Mug
(\$20)

Compact Mirrorless

→ All things being equal, a digital SLR will take a better picture than a compact camera. But the rigs are famously bulky. One reason: Their insides are filled with mirrors that take up a lot of space. The **Samsung NX10 Camera (\$700)** is part of a new breed of cameras that take the best parts of digital SLRs—their high-quality image sensors and ability to handle interchangeable



lenses—and cram them into a smaller, mirror-free shell. And even if it's not quite as pocketable as a compact camera, it's a lot smaller than an SLR.

Network Adaptor

→ Adoption of 4G WiMax networks, which promise faster anywhere-Internet than 3G networks, has advanced at a crawl. The **Sprint**



Overdrive 3G/4G Mobile Hotspot (\$100) is the most practical way of logging on to WiMax yet. Like other mobile hotspots, it converts airborne cellular signals into a

Wi-Fi feed that any PC can use to get online. If you're in one of the (still-too-few) WiMax-enabled cities, it uses that speedy signal. If not, it uses a 3G network as a backup.

Floor Fitter

→ Modular click-together flooring is ideal for beginning DIYers—until you need a table saw to make that last section fit against the wall. The **Skil 3600 Flooring Saw (\$160)** combines a table saw's rip fence and a radial arm saw's sliding blade to complete square rip cuts in hardwood, laminate and engineered flooring up to 8 inches wide and ¾ inch thick.



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Regal**

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\$28,000 (est.)

Inside:

MERCEDES-BENZ SLS AMG
LEXUS GX 460
KAWASAKI ER-6N
FERRARI 458 ITALIA
BMW ACTIVEHYBRID X6
INFINITI M37/M56
PORSCHE 911 TURBO
MITSUBISHI OUTLANDER GT
CHEVY VOLT PREPRODUCTION vs. TOYOTA PRIUS PLUG-IN

Changing Course

The new Buick Regal is a sport sedan. Really. Behind that Buick grille is the autobahn-conquering Opel Insignia—a successful European sedan for GM. The Regal slots in just below the 7-inches-shorter LaCrosse in the lineup, and the base engine is a 182-hp 2.4-liter four-cylinder mated to a six-speed automatic. The prototypes we drove in Michigan had the uplevel 220-hp 2.0-liter turbo

Four that should hit 60 mph in around 7 seconds and deliver 29 mpg on the highway. Compared with a LaCrosse, the Regal is the sharper, nimbler, more entertaining car. Turbo lag and torque steer are absent and the suspension is firm. If traditional Buick customers want a soft, floaty ride, they won't find it here. The Regal is evidence that a smaller, nimbler GM could be a good thing. — KEVIN A. WILSON

pm test driven ++

2011
Mercedes-Benz SLS AMG2010
Lexus GX 4602010
Kawasaki ER-6n

1

2

3

LEGEND REBORN

The wide, low-slung, leering grille of the new \$200,000 (est.)

Mercedes SLS AMG fills the rearview mirrors of lesser cars with an aggressive maw. Yet this is one of the most civilized supercars around. Duck under the gullwing doors and step across the narrow sill to drop into a supportive bucket seat, and you find yourself in an intimate cockpit. Just don't forget that there's a 563-hp 6.2-liter V8 under that long hood, with all the stunning performance you'd expect. Let the beast spin hard—the intensity increases spectacularly as the revs rise. It pulls so hard in the upper reaches that it's all too easy to run into the limiter beyond the 7300-rpm redline. Fun? Oh yeah.

— BARRY WINFIELD

Old Guard

Something about the new \$51,970 Lexus GX 460 seems archaic. It is old-school, off-road rugged in a world where most luxury SUVs have settled for being just tough enough to lug home a gallon of Rocky Road from the Safeway. It has a full ladder frame and a solid rear axle—just like its Toyota brethren, the 4Runner. The new 301-hp 4.6-liter V8 under its hood helps it tow a solid 6500 pounds. And the GX never feels strained or at a loss for thrust. Like many Lexus vehicles, the GX's suspension seems tuned to smother any hint of road conditions long before they're communicated to the driver. Off-road, the GX 460 really works. The suspension is supple, and the ride is composed even when bounding over basketball-size ruts and football-size rocks. When the going gets tough, the GX 460 will crawl over obstacles with precision and dignity. Considering its off-road prowess, the GX is among the best luxury SUVs for people who need to go where paved roads don't. — JOHN PEARLEY HUFFMAN

Confidence Builder

Newcomers to motorcycling face a range of sportbikes that are simply beyond their capabilities. But this Kawasaki isn't one of them. The \$6699 ER-6n is essentially a toned-down, naked and more forgiving version of the Ninja 650R. It has a steel frame, and the fuel-injected 649-cc parallel-twin engine is tuned for broad torque. And though the engine starts with a snarl, the relatively low saddle and upright posture make this bike welcoming. The seating position is comfortable enough for short and medium legs, but extended time in the saddle makes the pushed-against-the-tank position a bit uncomfortable. When the road surface twists, the ER-6n complies with quick turn-ins and nimble direction changes. Traversing canyon roads yields the most riding satisfaction and allows this Kawasaki's strongest asset—absolutely effortless handling—to shine through. — BASEM WASEF



BUICK REGAL | MERCEDES-BENZ SLS AMG | LEXUS GX 460 | KAWASAKI ER-6N |
FERRARI 458 | ITALIA BMW | ACURA ZDX | HONDA CRF1000L | HONDA CRF1000L
INFINITI M37 | M56 | PORSCHE 911 TURBO | MITSUBISHI OUTLANDER GT |
CHEVY VOLT | PREPRODUCTION VS. TOYOTA PRIUS PLUG-IN |

2010
Ferrari 458 Italia



2

2010
BMW ActiveHybrid X6



Benchmarker

Ferrari's early cars were dominated by V12 engines. But the midengined V8 sport coupes have been the backbone of the company's model range for the past 35 years. The latest is the swoopy 458 Italia. Press the big red starter, and the 562-hp flat-plane V8 whirs to life without a trace of temperament, sounding almost disappointingly quiet. Pull the right-hand paddle, and first gear engages with a slight thump. As soon as you touch the accelerator, the noise changes to a hardcore buzz as muffler valves open. At first, the 458 feels darty and abrupt. The steering is so sharp you could cut yourself, and it's very easy to overdrive this car in a series of twitching, elbows-out wheel movements. If you calm down and trust the steering, it starts to feel natural. Is it quick? Well, the 458 can hit 130 mph before a Toyota Prius gets to 60 mph. Let's not discuss fuel economy though, eh? — ANDREW ENGLISH

Aerodynamics play a big part in the 458's performance. Deformable winglets on the lower grilles direct more air under the car rather than into the radiators. The engine and transmission coolers duct air out the tail, which reduces air tumbling at the rear of the car. Downforce at its 202-mph top speed is 794 pounds, almost a quarter of the car's weight.

Hot-Rod Hybrid

The ultimate driving machine

The watered-down, disconnected driving experience conveyed by some hybrids would be inappropriate in a BMW, right? That's why BMW has tuned its execution of the two-mode hybrid transmission first for responsive performance. The electric drive is paired to the 400-hp twin-turbo V8, so combined, this \$89,725 X6 puts out 480 hp and a diesel-like 575 lb-ft of torque. The X6 whooshes effortlessly to freeway speeds and beyond with no indication of exertion. Off the line, the hybrid is quicker than the regular V8 X5 thanks to the torque from its electric motors, but within a few seconds the gas version would reel in the hybrid. BMW says it is possible to drive up to 1.56 miles in electric-only mode. But this state proved to be elusive on our test drive. More importantly, the modest 17-mpg-city and 19-mpg-highway ratings make this BMW's raison d'être a bit of a puzzle. — DAN CARNEY

BUICK REGAL | MERCEDES-BENZ SLS AMG | LEXUS CX 460 | KAWASAKI ER-6N |
FERRARI 458 ITALIA | BMW ACTIVEHYBRID X6 |
INFINITI M37/M56 | PORSCHE 911 TURBO | SUBARU OUTLANDER GT |
CHEVY VOLT | PREPRODUCTION VS. TOYOTA PRIUS PLUG-IN |

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To celebrate the return of the Olympic Games to North America, Canada is issuing a three-year silver dollar set. The 2008 issue, featuring the familiar Maple Leaf, quickly sold out. And then, this April, the mint cut off production of the 2009 Thunderbird issue. These are now sold out and unavailable. The 2010 silver dollar has just been released. There is no telling how long they will last, but *they could be gone in a heartbeat!*

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The first Olympic Games Commemorative coin ever was issued by Finland in 1951 at a cost of about \$13. Today that coin could cost as much as \$674. Not only are Olympic Games coins sought after, Canadian Silver



vancouver 2010



2010
Porsche 911 Turbo

2



1

2011
Infiniti M37/M56

3

2011
Mitsubishi Outlander GT

Hard Target

The midsize luxury sedan class is among the most competitive. The cars are not merely good—they're great. Into that maelstrom of excellence, Infiniti will later this spring launch its third-generation 2011 M37 and M56. We had a chance to drive prototypes recently, and found that despite the M56's 420-hp V8, the 330-hp six-cylinder M37 had the more engaging personality. Yes, the M56 is quicker, but that engine (at least in prototype) has no discernible exhaust note and a rather easygoing personality. In contrast, the V6 is one of the most eager and excitable powerplants on earth. The M56 wants to cruise, but the M37 wants to romp, rollick and spend the afternoon intoxicated by its own redline. Short of the turbocharged BMW 535i, the M37 may be the only six-cylinder-powered car in this class that a hardcore driving enthusiast could really love. — J.P.H.

Deja Vroom

Don't let the classic shape fool you. Porsche's new 500-hp 911 Turbo is every bit a supercar-level performance machine. The launch control boots the car out of the blocks with such vigor—all four tires clawing for traction—that drivers experience a few seconds of g-force giddiness. Since the car will only launch like this in the automatic-drive mode, it proceeds to snap off ultrafast shifts as the tachometer needle nears its 6800-rpm redline. Porsche engineers suggest a zero-to-60 mph sprint of 3.2 seconds is possible. Several revisions to the current 997 chassis have improved the Turbo's stability at speed and in the corners. The car's newfound predictability allowed the Turbo to circulate the Nürburgring's Nordschleife (northern loop) some 10 seconds quicker than its predecessor. On-road, the \$132,800 Porsche feels more responsive at the wheel yet at the same time exhibits composure, comfort and quietness. Is this the ultimate everyday supercar? Could be. — BARRY WINFIELD

EVOLUTION WAGON

One look at the new Mitsubishi Outlander's nose and you can tell where the inspiration lies—the Evolution sport sedan. But don't expect the Evo's turbocharged power here. The Outlander GT's 3.0-liter V6 gains a modest bump in power to 230 hp. Besides the thoroughly upgraded cabin, with soft-touch finishes and leather, the most notable aspect of the Outlander GT is the chassis. There's a new all-wheel-drive system and a suspension-and-tire combination that make twisty roads really fun to drive. We blasted up (and down) a mountain road outside Palm Springs, Calif., and found this Mitsu to be one very stable, very sticky and very predictable crossover. — BEN STEWART

BUICK REGAL | MERCEDES-BENZ SLS AMG | LEXUS GX 460 | KAWASAKI ER-6N |
FERRARI 458 | JAGUAR XFR | BENetton A123 | MITSUBISHI OUTLANDER GT |
INFINITI M37/M56 | PORSCHÉ 911 TURBO |
CHEVY VOLT PREPRODUCTION VS. TOYOTA PRIUS PLUG-IN |

POPULAR MECHANICS & OLD NAVY REV UP WITH NEW T-SHIRT COLLECTION AND COVER DESIGN CONTEST



Popular Mechanics has partnered with **Old Navy** to develop a collection of limited-edition T-shirts for kids! With these designs, inspired by transportation-themed *Popular Mechanics* covers, the rich 100-year history of this iconic magazine can now be enjoyed by our next generation of scientists, engineers and enthusiasts! Available in-store and at oldnavy.com while supplies last.

Kids up to the age of twelve are also invited to enter a contest to design their own *Popular Mechanics* transportation cover! In addition to having his or her design featured in an upcoming issue of *Popular Mechanics*, the winner will receive a \$500 Old Navy shopping spree. Look for the *Kids Do Great Things* entry forms at Old Navy stores from February 5 - February 21.



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Plug-In Hybrids Near Production

vs.

2011
Chevy Volt



2012
Toyota Prius Plug-In Hybrid



AS CITIES PREPARE FOR A WAVE OF NEW ELECTRIC VEHICLES, CHEVY AND TOYOTA ARE FINESSING THE TECH BEHIND THEIR EAGERLY ANTICIPATED NEW PLUG-IN HYBRIDS. WE DROVE BOTH PROTOTYPES.

The last time we test-drove a Volt prototype, it was locked in electric-only mode. But a brief stint recently behind the wheel of the car in charge-sustaining mode (once the 40-mile electric-only range is depleted, the gas engine doesn't charge the pack but rather provides the electric motor with precisely the amount of electrical energy it needs at the time) proved engineers have done a remarkable job tuning the car. When the 1.4-liter four-cylinder engine cut in during our drive, we barely noticed. If you're on a steep climb maintaining a high cruising speed, the gas engine might climb as high as 5000 rpm to meet the challenge. In that case, the engine's exertions will be very obvious. It sounds a lot like a car with a CVT. Engage Sport Mode and there's an additional 20 kilowatts available—making the Volt much more fun to drive. —BARRY WINFIELD

The plug-in Prius uses exactly the same hardware as the standard Prius. The biggest difference is the battery, a 5-kilowatt-hour/345.6-volt Panasonic unit with a nickel-lithium-oxide cathode, a carbon anode and carbonate-ester liquid electrolyte. It raises the trunk floor a couple of inches and adds 242 pounds. Like the standard, the plug-in wafts away using battery power alone. If you modulate your right foot off the floorboards and keep under 62 mph, and if there is enough juice in the battery, the Prius stays on battery power for up to 12.5 miles. In practice, this means the engine will stay silent in heavy traffic. The transition from battery to gas, which has consumed Volt engineers, is mercifully smooth here. Toyota expects fuel economy to improve 69 percent over the standard Prius, to deliver around 81 mpg. —A.E.

++ PM Test Driven



BUICK REGAL | MERCEDES-BENZ SLS AMG | LEXUS GX 460 | KAWASAKI ER-6N |
PERKINS 458 | JAGUAR ACTIVEHYBRID 40 | SUBARU OUTLANDER GT |
TESLA ROADSTER | PORSCHE 911 TURBO |
CHEVY VOLT PREPRODUCTION VS. TOYOTA PRIUS PLUG-IN |

RESTORING AN ICON

> BY JAY LENO
> PHOTOGRAPHS BY JOHN LAMM



AWAKENED FROM ITS DECADES-LONG DESERT SLUMBER, JAY'S 300SL GULLWING IS BACK ON THE ROAD.

Since I'm one of the few guys on TV who own old cars and enjoy restoring them, people often contact me about their car projects. Some are restorations that folks may have barely started. Others are vehicles they've labored over, but never quite finished. Then there are the cars that people have owned for 40 years, and now they ask me if I'd like to buy them so they end up in a good home.

That's how I came to own a 1955 Mercedes-Benz 300SL Gullwing. It was an old race car that its owners put in a storage container out in the California desert in the late 1970s. And the Mercedes just sat there for decades. I'm only the third owner. And that makes it special.

The 300SL was ahead of its time, with a tubular space frame, fully independent suspension, a fuel-injected SOHC Six, those cool gullwing doors and a lot of racing history. John Fitch won the GT Class in

the 1955 Mille Miglia, and finished fifth overall in what was basically a stock 300SL. But for me, it was always a car that was just out of reach. When I was in college in 1969, working for a Mercedes-Benz dealer, we took one in trade. We gave the guy \$5500 for it, which seemed like a lot of money back then. Within 10 days, we'd sold it for \$7200. We thought we'd pulled off quite a con job ... we got 7200 bucks for that thing.

We're restoring the mechanicals and the instruments on my Gullwing,

JAY LENO'S GARAGE/// GULLWING RESTORATION

but we'll leave the worn interior and exterior alone. I like not having to worry about a freshly sprayed, pristine paint job. It's very liberating if a screwdriver falls on the fender and makes a mark. You don't go, "Aaarrggghhh! The first chip!"

At some point, we will restore it completely. But there's something charming about having a car that's used for its original purpose—driving. I'll just tool around in this coupe for a while, and when enough purists get angry at me, we'll restore it. But right now, I can take it to Bob's Big Boy and if somebody wants to lean on it, I won't get upset. I don't want to be one of those guys who says "Hey! Hey! Heyyy!"

So far, we've redone the transmission, the brakes and the motor. We broke in the engine correctly—on the dynamometer. There's a diaphragm in the Bosch fuel-injection system that was originally made of some kind of lambskin. The original one was faulty, and the engine was running way too lean over the 3500 to 4000 rpm range. But we have a new one in now, and it's running much better. If we had installed the engine in the car without the dyno test, we would have probably melted a piston, and the engine would have been destroyed. But luckily, we caught the problem.

These 3-liter Sixes were supposed to develop 220 to 240 hp. We cleaned it up internally, did a little work to it, and we're seeing around 180 hp. I was disappointed, but I talked to a few Mercedes guys, and they said that was about right. It's like the Jaguar XKE—Jag claimed 265 hp, but it was probably more like 210 hp. Back then, everybody lied about horsepower.

The 300SL has beautiful finned brake drums, but a chunk of one drum was missing. We could have



The 3.0-liter inline Six (left) in Jay's 300 SL now runs smoothly thanks to the engine dyno. This Gullwing is no trailer queen—it's built to drive hard.



made a new one with our CNC machine, but instead we called the Mercedes-Benz Classic Center, which has parts for just about every car the company made. They're not inexpensive, but try to find one anywhere else. It's brand-new, and it's made by Mercedes-Benz. Every Gullwing part is available from the Classic Center.

Honda used to do that. When Soichiro Honda, the company's founder, was alive, he vowed that every part for every Honda motorcycle would always be available. But once he died, they brought in the accountants who said it wasn't viable to keep Honda 50 leg shields in stock. Yet Mercedes-Benz has always produced those parts, and that makes people bond with the brand.

They built just 1402 300SL Gullwing coupes, but it was enough to support the spare-parts market. If you write a book on the Gullwing, you'll always sell at least 1400 of them. If you write a book on, say, the Jackson car, made in Michigan until 1923, you'll sell five. There might be five Jacksons left out there.

My vintage 300SL Gullwing will be finished at about the same time the new SLS AMG Gullwing hits the road

(see "New Cars," page 35). And the old ones still cost more than those brand-new ones. I think that's funny, but I do like to see the heritage carried on. The Gullwing works because there's a bit of theater involved. The car requires some effort: You can't just get in and drive it. There are certain things you have to know about, whether it's as simple as the flip-down steering wheel or the heater controls. You sort of pilot these cars; you don't necessarily drive them. You have to understand the handling limitations of those swing axles too—in high-speed corners they can be a handful. Consequently, you tend to drive a bit more carefully.

I'm not one of those people who have to have the ultimate 300SL with the knockoff Rudge wheels either. That's just extra cake frosting. I think the regular hubcaps and steel wheels look a little nicer. The knockoffs can loosen and come off, and I don't want to drill them and put safety wire on them. With lug nuts, I know what I'm doing. It's like women who wear those high heels. "Yes, but they're really attractive," they'll say. And I think to myself, "But they're uncomfortable!"

The Gullwing isn't our only Mercedes project. I bought a 6.3-liter 600 sedan from the 1960s with 324,000 miles on it—my favorite Mercedes from a styling and performance point of view. I thought, why don't we install the modern 6.3-liter V8? So we're putting in a new AMG 563-hp V8, like the one in the SLS, with a seven-speed transmission. We'll turn it into the ultimate 6.3 Mercedes-Benz. Stay tuned.

PM

Long-Term Test Cars

OUR DIESEL JETTA WILL BE MISSED, BUT THE HONDA INSIGHT PICKS UP THE MPG BATON.

+
PM TEST
DRIVEN
+



+ Honda Insight EX Navi

FIRST report

Welcome back, Insight. The original and forward-looking Insight hybrid left Honda's product line in 2006. It was a pioneering vehicle, but it was too small and had too (or perhaps two) few seats. Now the nameplate has returned in an infinitely more practical package, albeit without the industry-

leading fuel economy of the first one. But the new four-door Insight is still a mileage champ. On a recent test (see Nov. '09), the Insight delivered a thrifty 45.3 mpg on our city loop and 43.3 on the highway. Those are solid numbers. But we knew we could do better. So we decided to add an Insight to our

long-term fleet. The Insight is propelled by a small 98-hp 1.3-liter four-cylinder—not much oomph for even a featherweight 2730-pound vehicle. But add in the 13 hp and 58 lb-ft of torque produced by the electric motor and it's at least capable, if not quite brilliant, in traffic. We ordered the

VITAL STATISTICS Base price \$23,100 : As-tested price \$23,800
Extra-cost options None : Drivetrain 1.3-liter four-cylinder with hybrid drive, CVT
Engine performance 98 hp/123 lb-ft : EPA fuel economy 40 city/43 highway



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LOT NO. 95275

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CENTRAL PNEUMATIC

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\$149.99

REG. PRICE \$289.99

SAVE \$140

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Item 38082 shown

LOT NO. 38082/46005

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\$7.99

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upscale EX Navi trim, which comes with the high-end stereo and, of course, the navigation system. The package included Bluetooth and wheel-mounted controls for the stereo, phone and cruise control. There really aren't any other options available. Overall, the Insight has sipped fuel—hovering around the 40-mpg mark in commuting service, although we did have one particularly impressive run. On the New Jersey Turnpike, traveling with the wind at our backs, the computer said we touched 47 mpg for more than 50 miles. Not bad with four adults and a modest amount of luggage. —MIKE ALLEN



We've enjoyed driving around with the fuel-economy display because it teaches you, fairly rapidly, how to motor along with a feather foot.



Audi A4 Avant 2.0T Quattro

SECOND report

Some cars just make you feel smart. And this is one of those cars. The 2.0-liter turbo delivers nearly lag-free torque that belies the engine's size, and the six-speed automatic practically predicts your moves. It adds up to performance that's more precise than exhilarating—almost cerebral, but in a good way. Inside the cabin, Audi has assembled one of the sharpest user interfaces. Audio, nav and climate controls are handled through the Multi Media Interface (MMI), a scroll-wheel/button combination that operates somewhat akin to a computer mouse. Once you get the hang of it, you can dial in radio stations or climate settings almost entirely by touch. We've put over 10,000 miles on the Avant so far. Our first service was hassle-free, and, aside from a couple of fluky TPMS warnings, the vehicle has offered zero headaches. Driven with restraint, the Avant delivers good mileage. (But, like all turbos, it sucks fuel with abandon if you have too much fun.) And the wagon configuration handles all the cargo you can throw at it, but still feels sporty and looks sophisticated. —JIM MEIGS

**DRIVERS
NOTEBOOK**

- Wipers could use a faster top speed for monsoon conditions.
- We've gotten a couple of false TPMS warnings

even when the tires are inflated to spec.
• How did we park in the days before reverse cameras and proximity warnings?

DATA SO FAR

As tested :
\$43,050
Previous reports :
See 11/09
Miles driven :
10,296
Miles since last report : 5440

Fuel economy :
Average—23.4 mpg
Worst—18.0 mpg
Best—31.9 mpg
Maintenance/repair : scheduled service, no charge



Dodge Ram 1500 Laramie Crew 4x4

THIRD report



We've worked the Ram hard over the past few months. It crossed the Rockies—not once, but twice—and towed a race car to Watkins Glen, N.Y., racking up 8500 miles in just five weeks. And our admiration for this rig continues—it's a capable and plush workhorse. The Ram is the only full-size pickup with a coil-spring rear suspension, which provides an exceedingly smooth and controlled ride. Even when hitched to a 7000-pound enclosed car hauler, the truck tracks impressively straight. And the rear-view camera really takes the guesswork out of trailer hookups. But when towing, fuel economy fell to a frightening 6.4 mpg. With 390 hp from the Hemi V8, we have yet to find a load that taxes the powerplant. While we were initially disappointed that the

RamBox has a smallish bed, the lockable fender compartments are great for safely storing our tools. Mechanically, the Ram's record has been spotless. And in this economy, service thrif is especially important. —LARRY WEBSTER

DRIVERS

NOTEBOOK

- While crossing 10,000-foot Colorado passes, the Ram barely noticed the power-sapping altitude.
- The Uconnect system does it all, from wireless phone connectivity to seamless iPod integration.

DATA SO FAR

As tested :
\$52,520
Previous reports :
See 08/09,
11/09
Miles driven :
11,539
Miles since last
report : 9317
Fuel economy :
Average—13.3
mpg
Worst—6.4 mpg
Best—18.3 mpg
Maintenance/
repair : \$90.23



VW Jetta TDI Loyal Edition

FINAL report

As much as we've praised the Jetta's torque and fuel-efficient diesel powertrain, it was the smart touches inside that made the commutes and road trips a breeze. On one getaway weekend from L.A. to San Diego, we found the trunk cavernous enough to haul our baggage—and all our SeaWorld trinkets—home. Today's vehicles have added more and more techy gadgets, so it's refreshing to see some simplicity. We dug the clean design of the Jetta's dash, with just two basic knobs to control the radio. Some luxury cars have thinly padded center armrests. Not this Jetta. Its pleasant elbow perch is not only exceedingly cushy but also height-adjustable, so all drivers can find a comfortable spot. During our year with the Jetta, we had two tire punctures. Because the TPMS told us, we took the sedan in right away to get patched up. We'll miss the Jetta's practicality, efficiency and, of course, all those little things that make this car so easy to live with. —CARI NELSON

DRIVERS NOTEBOOK

- There's no guarantee you'll get hybrid-like fuel economy on every tankful. But with careful throttle application on the highway, you'll see 40 mpg.
- It's still sometimes difficult to find diesel with any consistency. Good thing this car can travel close to 600 miles on a tankful.

END DATA

As tested :
\$24,190
Previous reports :
See 05/09,
08/09, 11/09
Miles driven :
11,448
Miles since last
report : 1444
Fuel economy :
Average—30.6
mpg
Worst—24.2 mpg
Best—40.7 mpg
Maintenance/
repair since last
report : \$50
Overall : \$50



OVER THE



HORIZON

AS AN UNMANNED REVOLUTION RESHAPES THE U.S. AIR FORCE, WAR, POLITICS AND BUDGET CRUNCHES COULD DRIVE THE PENTAGON TO TRUST INTELLIGENT ROBOTS WITH ONCE UNIMAGINABLE AVIATION JOBS.

BY JOE PAPPALARDO

<u>DATE</u>	<u>LOCATION</u>	
2025	Hangar 23, U.S. Forward Operating Base	
<u>AIRCRAFT</u>	<u>UNIT</u>	
MQ-Mb multirole fighter prepped for a precision strike mission	U.S. Air Force Expeditionary Fighter Squadron	
<u>POSSIBLE PAYLOAD</u>		
Air-to-ground missiles, radio surveillance gear, high-definition video cameras, communications relays, nonlethal microwave-energy beams, 2000-pound precision bombs		
<u>LENGTH</u>	<u>WINGSPAN</u>	<u>PILOTS</u>
45 feet	32 feet	Zero
<u>THE NEW AIR FORCE: PILOTS OPTIONAL</u>		
The Air Force is planning to build a fleet of unmanned warplanes that will fly and fight without human guidance. The next-generation aircraft envisioned by the Air Force, and modeled in the illustration opposite, would be able to dodge enemy radar, swap payloads for multiple kinds of missions and use sophisticated onboard sensors to prevent collisions with other UAVs and manned airplanes.		

Like its waterfowl namesake, the Heron unmanned aerial vehicle has the excellent vision of a hunter. Today, the 27-foot-long Israeli UAV is making a rare flight over the United States, using a high-definition video camera to track a speedboat buzzing across the Patuxent River in Maryland. The camera shares space with an infrared thermal imager and laser rangefinder inside a 17-inch sphere mounted under the aircraft's nose. The camera and the UAV both turn automatically to track the boat below, no satellite-linked joysticks required. On the Patuxent, a Coast Guard crew in a shallow-water patrol boat uses a real-time video feed from the Heron to locate the speedboat.

Less than 5 miles away, several hundred spectators watch the camera's feed on a massive color television monitor. The crowd of defense officials, defense industry wonks and military aviation buffs—many with bumper stickers on their cars that say “My other vehicle is unmanned”—is thick here at Webster Field, an auxiliary naval airfield in Maryland. The Heron is just one of about a dozen UAVs making flight demonstra-

RENDER BY MIKE HILL

tions. As each one sweeps overhead, an announcer gushes over its abilities with the over-enthusiasm of a county fair emcee describing a prize sheep.

The crowd watches on the massive screen as the two boats converge and the Coast Guard crew completes the mock interception. The image of the river scene wheels as the Heron banks away from the boats and returns to the airfield. The UAV glides into a smooth, autonomous landing and as the Heron taxis, the goofball emcee coos over the PA speakers: "Aw, isn't that just pretty?"

The day is a spectacle of flying robots. A unit of Textron shows off an aircraft that it is pitching to the Marine Corps. It has a 12-foot wingspan and a pusher propeller mounted between its fuselage and inverted V-tail; it can be launched from a moving vehicle and is recovered by flying it into a net. The U.S. Army also has a marquee UAV to demo, the MQ-8B Fire Scout. The 3150-pound unmanned helicopter, the Army's first, may soon scan battlefields for chemical weapons, minefields and radio transmissions. And the showstopper, even while remaining earthbound, is the Navy's Joint Unmanned Combat Air System, a sleek, blended-wing aircraft with the maw of an air inlet placed almost mockingly where a cockpit would go. It sits like a resting bird, its 31-foot-long wings folded up for better storage on a warship. It is scheduled to perform an autonomous takeoff and landing from an aircraft carrier deck this year.

With all the hardware and enthusiastic attendees, it's easy to overlook a missing guest—the U.S. Air Force. Of all the advanced aircraft on the flight line, none is being developed for Air Force programs or is controlled by the service's airmen.

Unmanned aircraft are the biggest thing to happen in military aviation since stealth geometry, and the Air Force's leadership is dramatically increasing the UAV fleet this year. However, the service is still struggling over how the technology can be maximized

in the future. "Today, the evolution of the machine is beginning to outpace the capability of the people we put in them," Air Force chief of staff Gen. Norton Schwartz said late last year in a speech to the Air Force Association. "We now must reconsider the relationship."

Under his direction, the Air Force is trying to become the Pentagon's leader of future UAV development. Schwartz's primary tool is the "Unmanned Aircraft Systems Flight Plan, 2009–2047," a comprehensive look at how the U.S. military can expand the use of UAVs over the next 38 years. The Air Force is proposing to use next-generation unmanned aircraft in a slate of new missions, including air strikes, aerial refueling, cargo transport and long-range bombing.

But how much freedom will the Air Force be willing to grant unmanned air-

planes? Its airmen are only now coming to accept UAVs—they fly them every day over Iraq, Afghanistan, the Horn of Africa and other hot spots—but the service has articulated a way forward that not only marginalizes pilots, it also promises to replace many UAV ground-control crews with automation. Today's highly trained airmen may not embrace this vision of the future. One Air Force officer working with unmanned aircraft would only say he supports the report "because it's a plan. And having a plan is better than not having a plan."

Misfit Toys to Frontline Heroes

The Air Force squandered decades' worth of opportunities to lead U.S. military UAV development. In the 1970s, the service experimented with unmanned surveillance craft in Vietnam but dropped all funding after it decided the technology did not offer improvements over traditional airplanes. Continued advances of Soviet warplanes, such as the MiG fighter, kept a Cold War premium on air superiority won by high-performance, expertly piloted airplanes.

The idea of unmanned airplanes also runs contrary to the airman-centric ethos that has defined the Air Force since it became an independent military branch in 1947. *Aviation Week and Space Technology* magazine in 1973 quoted an Air Force official's disparaging verdict on remote-control warplanes: "How can you be a tiger sitting behind a console?" That attitude proved to be shortsighted. In 1982, Israel used UAVs to spoof Syrian radar in Lebanon, but the status quo in America continued for another decade. The Pentagon started UAV research in the mid-1990s, but even then the funding was tepid, in part because of Washington's bias toward large, job-generating manned airplane programs.

Guerrilla wars in Iraq and Afghanistan changed all that; the need for constant overhead video is driving a UAV spending spree. When facing insurgents who blend into a local population, good intelligence is worth more than even the




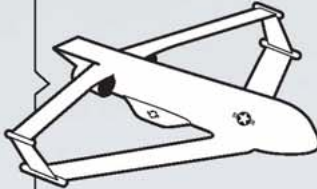


"I don't think it's an overstatement that this is a revolution of military affairs. The revolution is the conscious application of automated technology."

COL. ERIC MATHEWSON
UNMANNED AIRCRAFT
SYSTEMS TASK FORCE
DIRECTOR



THE REPLACEMENTS

THE AIR FORCE ENVISIONS SWAPPING ITS PILOTS FOR A FLEET OF VERSATILE—AND AFFORDABLE—UNMANNED AIRPLANES. A SINGLE UAV WITH INTERCHANGEABLE PAYLOADS COULD REPLACE SEVERAL LEGACY AIRPLANES. HERE'S A LOOK AT SOME POSSIBLE TRADES.

PRESENT			FUTURE
<p>F-16 FIGHTING FALCON This oft-upgraded multirole warplane has proved itself in dogfights and air strikes since 1979.</p> <p>MC-12W LIBERTY In 2009 this plane began flying battlefield surveillance missions.</p>			<p>MULTIMISSION UAV Medium-size UAVs will swap onboard gear and weapons to intercept communications, bomb ground targets or fight enemy aircraft. This year the Pentagon will select a design for a 2015 replacement of the MQ-9 Reaper.</p>
<p>KC-135 STRATOTANKER This 136-foot airplane can offload 6500 pounds of jet fuel per minute but fills only one airplane tank at a time. The average age of the Air Force's fleet of tankers, flying since 1957, is now more than 40 years.</p>			<p>JOINED-WING AERIAL REFUELING UAV A box-wing UAV could fuel many airplanes at the same time and loiter, perhaps for a week, until needed. The Pentagon is spending more than \$40 billion on manned refuelers, but unmanned tankers could be built to service UAVs.</p>
<p>B-2 SPIRIT Since 1989, this stealth bomber's mission has been to attack well-guarded ground targets.</p> <p>U-2 DRAGON LADY This unarmed, high-altitude recon airplane, in service since 1957, can fly 12-hour missions.</p>			<p>LONG-RANGE SURVEILLANCE BOMBER This stealth UAV could monitor a target for days—and then destroy it at the time of a commander's choosing. The Air Force hopes to restart its bomber program this year; the new aircraft will likely be able to fly with or without a pilot.</p>

AIRCRAFT NOT TO SCALE



When unmanned aircraft can refuel one another, their time on a mission will be dramatically extended. The Air Force Research Laboratory is spending \$49 million over the next four years to create a system that will allow UAVs to autonomously refuel in the air, as seen in this 2007 Predator test.

smartest bomb. In 2010 the Defense Department will spend \$5.4 billion on unmanned aircraft development, procurement and operations—about \$2.5 billion more than the military spent on UAVs during the 1990s.

This boom is causing turf wars within the Pentagon. Military branches seldom develop weapons systems together, despite the potential savings of time and money if the services shared research costs and ordered hardware in bulk. The Air Force wants to coordinate UAV development within the Pentagon and drafted its ambitious Flight Plan to describe how the service would serve as the Pentagon's chief guide to unmanned airplane development, in concert with the Army, Navy and Marine Corps. "The Flight Plan is part of an Air Force effort to lay claim over everything that flies, whether it has a pilot or not," says military analyst and author Jim Dunnigan.

The Unmanned Aircraft Systems Task Force, which drafted the plan, is headquartered in a modest office that takes up a small fraction of one floor inside a banal building in Crystal City, Va. The full-time staff here tops out at a handful, but National Guard and Air Force Reserve temps fill out the administrative positions. Dozens of moonlighting planners from the Pentagon also volunteer for the task force, forgoing their free time for a chance to work on a project with high-ranking luminaries at Air Force headquarters who advise the task force.

The day-to-day work is supervised by the task force's director, Col. Eric Mathewson. The former F-15 pilot is a compact man with a soft, smooth voice that always sounds earnest. Mathewson often places a hand on his head when he speaks, as if his ideas could burst from his temple if he weren't holding them in. "It was clear we had been reactive, reactive, reactive," Mathewson says. "It was time to develop a vision."

That vision depends on developing smarter unmanned aircraft that can make life-and-death combat decisions

"Unmanned aircraft systems [UAS] will fly autonomously to an area of interest while avoiding collisions with other UAS in the swarm. These UAS will automatically process imagery requests and will 'detect' threats and targets through the use of artificial intelligence."

U.S. AIR FORCE UAS
FLIGHT PLAN, 2009–2047

on their own. According to the Flight Plan, UAVs will demonstrate "sense and avoid" collision-avoidance systems by the end of this year. Unmanned aircraft will be able to refuel each other by 2030. Global strike capability, perhaps even with nuclear weapons, is projected for 2047. "As technology advances, machines will automatically perform some repairs in flight," the Flight Plan reads. "Routine ground maintenance will be conducted by machines without human touch labor." The Air Force document not only discusses once-taboo subjects, such as automatic target engagement and autonomous UAVs flying in commercial airspace, it also includes short-term recommendations and goals to one day make them feasible.

Mathewson says that by 2020 just one

control crew—airborne or ground-based—will be able to control multiple UAVs at once. Ground-control crews today, even when aided by advanced autopiloting, continuously monitor a single UAV. This level of direct control and supervision is referred to as man-in-the-loop. But a robotic system that only alerts humans when a critical decision needs to be made is called man-on-the-loop. A ground-control crew can opt to redirect the UAV or assume direct control until the key choice is made. "I don't think it's an overstatement that this is a revolution of military affairs," Mathewson says. "The revolution is the conscious application of automated technology."

Robot-Assisted Air Strike

Man-on-the-loop controls could make a battlefield look like this: An F-35A Lightning II fighter cuts through the night sky. The pilot's mission is simple—destroy an enemy bunker protected by a network of radar and antiaircraft missile batteries. His three wingmen—one flying scant feet away, another 150 miles ahead and the third preparing to cause a diversion far to the east—are following a meticulous battle plan meant to defeat these defenses. Of the four aircraft in the strike group, only the F-35A has a cockpit; the rest are semiautonomous UAVs that the pilot must trust with his life.

One of the most dangerous missions in military aviation is suppression of enemy air defenses, or SEAD. The lead UAV becomes bait as it flies into radar range of antiaircraft missile batteries. An icon on the F-35 pilot's virtual head-up display, projected onto the faceplate of his helmet, alerts him that the SEAD unmanned airplane has automatically identified the emissions of an enemy radar site. This is the first time in the mission that the SEAD airplane has communicated with any human.

Col. Pete Gersten commands the 432nd Air Expeditionary Wing at Creech Air Force Base, Nevada, the only wing dedicated to unmanned airplanes like the MQ-9 Reaper (shown). Gersten is eagerly seeking crews to operate UAVs, but isn't ready to replace them with software.



EXPERTS WEIGH IN

GUY BEN-ARI

SENIOR POLICY ANALYST, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

"I think the Flight Plan is a serious document. It's not just discussing the technology, but the policy, the legislation, the ethical framework. The whole package needs to be developed in parallel as these technologies mature."



P.W. SINGER

AUTHOR, WIRED FOR WAR, THE BROOKINGS INSTITUTION



"The road map to 2047 will likely be good for just a few years. But that's all we need for it to make a big difference."

JIM DUNNIGAN

AUTHOR, ANALYST, STRATEGYPAGE.COM



"The other services are pushing ahead with their UAV efforts without paying much attention to the Air Force. No one has any idea what the tech will be in 2017, much less 2047. In 2047 we'll have stuff as unfamiliar to us as today's tech would be to someone in the late 1940s."

Miles from the danger, the F-35A pilot coolly assesses the situation displayed on one of the screens in his cockpit, confirms the target is legitimate and authorizes the lead UAV to fire. The AGM-88 high-speed antiradiation missile follows the radar waves back to their source, obliterating the dish and its crew. There is now a gap in the enemy radar screen, and the pilot directs the UAV to return to base.

Meanwhile, another UAV east of the target, navigating by using a mix of GPS and accelerometer data, is busy scrambling other enemy radar installations by flooding the skies with emissions that share the radar's frequency. The jamming pods under the UAV's wings also disrupt radio transmissions from the air-defense network, covering up the sudden loss of contact with the radar sites protecting the bunker. Otherwise, an enemy commander could discover the location of the actual raid. After a preset amount of time spreading confusion, the UAV returns to base.

The F-35A pilot is closing in on the target fast and needs to carefully aim the F-35's electro-optical targeting system to release a bomb that will hit the structure at an angle calculated to collapse it without destroying nearby civilian buildings. He triggers the laser designator and authorizes the nearby unmanned

airplane to drop a pair of bombs, which use fins to steer toward the laser-designated sweet spot. The pilot watches the twin, concurrent explosions, makes a quick battle-damage assessment and, satisfied, banks the airplane and heads back to base. His robotic wingman follows his lead, flying evenly at his side.

Skeptical Views From the Front

It can be hard to see the Flight Plan's vision of autonomous flying robots from the human-intensive work being done at Creech Air Force Base in Nevada. The desert base is in the midst of an unprecedented boom as it hosts the fast-growing 432nd Air Expeditionary Wing, the only one dedicated solely to flying unmanned aircraft. Every aircraft and satellite-linked ground-control station here is being used to fly missions in the Middle East, the Horn of Africa and points beyond. New buildings fill up with staff as soon as the construction dust settles. "Every time the fishbowl grows, the fish get too big for it," says Col. Pete Gersten, the 432nd's commander. Mathewson served at Creech as group commander before Gersten's arrival, but their jobs now are pointed in opposite directions. As Gersten wrestles with recruiting ground-control crews, Mathewson promotes ways to replace the airmen with artificial intelligence.

Every time an airman is replaced by a machine, the Air Force cuts the cost of health benefits, base upkeep and recruitment. Current unmanned systems require as many, if not more, people to fly missions than piloted airplanes do. For example, it takes a crew of three to operate a Reaper, even while it's on autopilot: one to fly, another to operate the sensor ball in its nose and a third to serve as military intelligence liaison. Another pair must deploy to the forward airfield to guide the UAV, using line-of-sight radio during takeoff and landing. By replacing these positions with automated functions, the cost of joystick operators could plummet.

But Gersten—who calls his unmanned airplanes remotely piloted vehicles to emphasize the crews operating them—does not give up human control over the aircraft unless it provides a clear war-fighting edge. For example, the Flight Plan pegs autonomous takeoff and landing for the Reaper by the end of 2010, but Gersten is not begging for that ability. In fact, when faced with a rash of accidents during landings, Gersten chose a solution to help, not replace, the joystick pilot.

The landing gear would collapse when Gersten's UAVs bounced down the runway. Operators have a tough time finding the correct pitch of the nose after



a UAV's wheels bounce off the runway, causing oscillations that can destroy the aircraft on the third or fourth bounce. The seemingly obvious solution: Program the machines to take over and land automatically—something the Army's Sky Warrior, which is nearly identical to a Predator, already does. But Gersten opted for a simpler fix, adding a triangular carrot icon on the flight-control screen that sets the correct pitch to prevent the oscillation cycle from starting. This change will be made to ground-control stations this year, and he says "the cost is minuscule."

Gersten's reaction to the Flight Plan is coolly receptive. (He rolls his eyes at the report's language that suggests that UAVs one day could carry nuclear weapons.) The lower ranks on the base are more frankly skeptical of autonomy. Senior Airman Jessie Grace, a sensor-operator instructor at Creech, has spent wrist-aching hours keeping a UAV's camera trained on a target vehicle or locking his tired eyes on display screens to catch subtle signs of insurgent activity. While he does say that pilots could control more than one airplane at once, Grace sees things differently when it comes to his specialty. "I can't imagine a computer doing intelligence, surveillance and reconnaissance better than a person," he says.

Even as the Air Force frantically expands its fleet of MQ-9 Reapers—hoping to field more than 300 by the end of 2010—the service is seeking a tougher, faster and smarter successor. "We are going to replace them before they fail," says the wing commander in charge of the Reapers.

Mathewson lists battlefield demands as the biggest hindrance to the Flight Plan, but he notes inflexible attitudes as another roadblock. "You see a cultural resistance," Mathewson says. "It's the same thing with the horse cavalry during the introduction of the tank."

Programmed Killer Instincts

Until the Flight Plan, it was nearly impossible to find officials who would even discuss the possibility of unmanned airplanes firing their weapons without human permission. But the report states that by 2030, flying robots could be programmed with "automatic target engagement" abilities. A UAV would open fire only after clearing a checklist of technical details from its sensors—its preset rules of engagement. Such a system would be an heir to ones currently used in Patriot antiaircraft batteries and some antimissile weapons on Navy ships. The legacy of the Patriot is mixed. During the second Gulf War, the system downed a pair of friendly airplanes, killing one American and two British pilots, after mistaking the planes for enemy missiles. Many

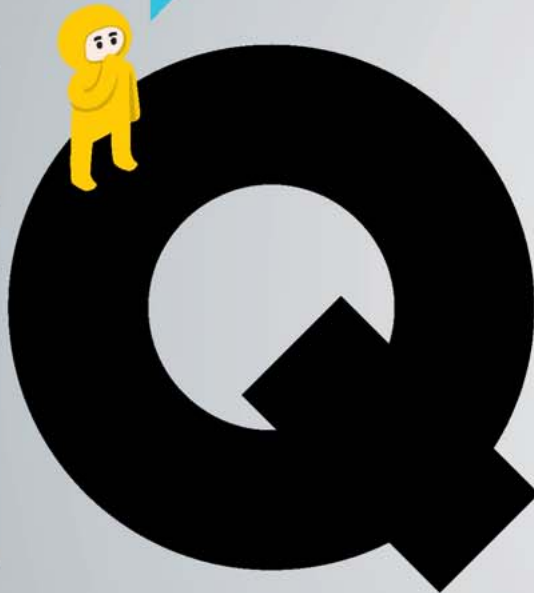
military officials faulted an over-reliance on automation, but think-tank analysts noted that a lack of training caused the dependence and was the root cause of the tragedies.

Mathewson says that keeping people directly involved at the end of the kill chain is optional but preferred. "There are not that many cases where you'll have free fire, where you're going to have the system completely automated," he says. "If you look at the way we employ unmanned aircraft in the current fights, the rules of engagement require that someone [in charge at the rear] has to approve it, to say, 'Yes, indeed, you're cleared hot' for every single case. And that would hold true."

While Gersten normally keeps any pride in check, the former F-16 pilot can be moralistic in arguing to have a man at the helm of a system that can bring death to its targets. "Warfare should be humanistic," he says. "Human value requires a human interface." It's his way of saying that even sworn enemies deserve to have an actual person, rather than an algorithm, make the decision to kill them.

PM

TEST YOUR D I Y



So, you know how to build, fix or customize anything, huh? We'll see about that.

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BY HARRY SAWYERS

PHOTOGRAPH BY JAMES WORRELL

1. You just poured a concrete slab for your new patio, and you have an itch to wheel out the grill. To get wet concrete to cure properly, you should:

- **A. Expose it to sunlight**
- **B. Sprinkle it with silica gel**
- **C. Put a fan on it**
- **D. Cover it to keep it moist**

2. Six pieces of information appear on a tire sidewall label that reads P245/40ZR18. P means "passenger car," 245 is the width of the tire (in mm) when mounted, and 18 is the diameter of the rim in inches. Which of the following is *not* indicated by the 40, Z and R in the middle of the code?

- **A. Aspect ratio**
- **B. Optimal air pressure**
- **C. Speed rating**
- **D. Construction**

3. You're always on your ladder, either keeping the gutters spic-and-span or rescuing local cats trapped in trees. So you know the rung rules: Which ladder step is safe to stand on?

- **A. Top cap**
- **B. Rear step**
- **C. Top step**
- **D. Second step**



4. Some recent experimentation with gas-saving gadgets gave you a pleasing, placebo-charged feeling of success, but the numbers didn't show any fuel savings at all. Changing your driving behavior is more likely to get the results you seek. Which of the techniques below will actually improve your fuel economy?

- **A. Increasing tire pressure**
- **B. Accelerating more gently**
- **C. Turning off the a/c**
- **D. All of the above**

5. After spending a year in the woods building your midlife crisis cabin with an axe and mallet, you're ready to return to the world of power tools. Which of the following saws' blades should *not* be moving when it makes contact with the material to be cut?

- **A. Chain saw**
- **B. Circular saw**
- **C. Miter saw**
- **D. Reciprocating saw**



6. Of the four chains at left, only one can successfully be used as a “drop chain” to help snake wiring behind walls. (Hint: It’s a link to the past.) Name that chain.

- A. Snow-tire chain
- B. Window sash-weight chain
- C. Chain-saw chain
- D. Bicycle chain

7. You want to insulate the attic, and you're fairly hip to the latest in high-tech heat retention. Fiberglass batts have a thermal resistance rating (or R-value) of 3.1 to 4.3 per inch, and higher R-values mean better efficiency. How do new products compare to the big pink? Identify the insulation with the highest R-value from the list below.

- A. Mineral wool
- B. Cellulose
- C. Polyurethane spray foam
- D. Recycled blue jeans

8. The hammer is your primary problem-solving tool—you're just that type of craftsman. When hammering machined surfaces or fragile parts, which type of tool is inappropriate to use?

- A. Lead hammer
- B. Ball-peen hammer
- C. Brass hammer
- D. Rawhide hammer

9. You're laying a floor that will be used regularly to host plus-size stiletto square-dancing night. You need the hardest wood available—which of these is your material of choice?

- A. Maple
- B. Cherry
- C. Hickory
- D. Bamboo

10. You're pressure-washing the patio with a 40-degree nozzle, moving the tip side-to-side in a slow sweep about a foot from the concrete. But stains under the bird feeder aren't coming up. For more power and a focused beam, which nozzle size do you need?

- A. 15-degree nozzle
- B. 60-degree nozzle
- C. Third-degree nozzle
- D. No nozzle; just put your thumb on the hose tip

11. You're convinced that modern paint chemistry is a conspiracy—the low-VOC trend, in particular, rouses your suspicions—so you prefer to use a traditional oil-based alkyl whenever possible. Which job is ideal for an oil-based paint, rather than a new latex acrylic?

- A. Interior drywall
- B. Exterior stucco
- C. Exterior ironwork
- D. Interior woodwork



12. You spread mulch because you think it's pretty, but you don't like to admit that to your rugby pals. It's practical, you say—when spread around shrubs, mulch retains moisture, inhibits weed growth and keeps roots from overheating. To maintain your cred in the scrum, when should you apply mulch, and how much of it?

- A. Apply liberally in spring—can't have too much of a good thing
- B. Sprinkle less than 2 inches when the heat hits 85 F
- C. Spread 2 to 4 inches over cool, moist soil in springtime
- D. Real men don't mulch

13. The cheapo lug wrench that the manufacturer threw in the trunk is demonstrating its shortcomings—it won't loosen the tire's lug nuts. What's the best way to get the stuck nuts moving?

- A. While holding the wrench steady on a nut, kick the tire to depressurize the fastener
- B. Fit the wrench on a nut, slip a 3-foot pipe snugly over the wrench end, and pull the pipe end counter-clockwise
- C. Turn the wrench clockwise; stuck lug nuts are often reverse-threaded
- D. Hold the wrench on a nut while a helper quickly drives the car in reverse



15. When the local GM dealership liquidated its inventory, you scored a compressor almost as big as a Buick. The 60-gallon beast runs at 3 hp and blows an average of 10.2 cfm at 90 psi. Still, it's limited—which of these tools could it *not* power?

- A. Brad nailer
- B. 3/8-inch impact wrench
- C. Orbital sander
- D. Finish nailer

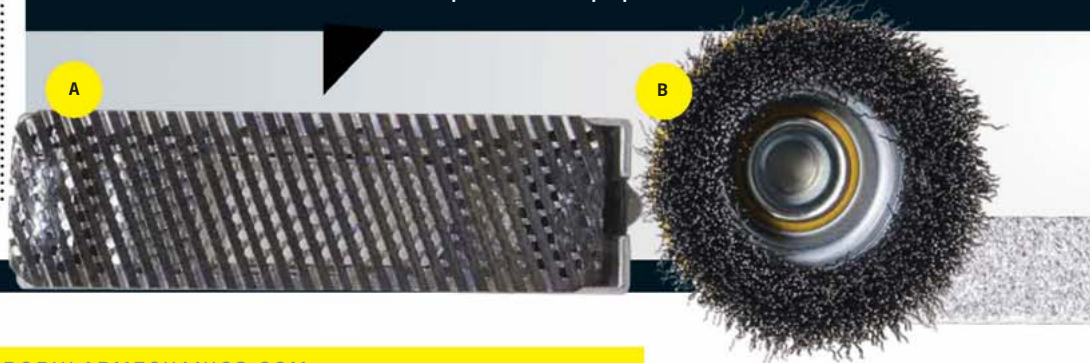


16. Winston butts that visiting kinfolk stomped into your old oiled pine floors have left some unsightly blemishes over the years. To patch a damaged section, you cut out a sooty spot with a plug-cutter, fashion a matching plug to fit it, sand it flush and oil the area. The repair you've made is called a:

- A. German repair
- B. Scotsman repair
- C. Dutchman repair
- D. Myanmanman repair

14. The world of abrasives doesn't start and end with sandpaper. The following tools can reshape surfaces in a hurry—but only one item has the scour power to take rust off ferrous metal parts. For coarse credit, which is it?

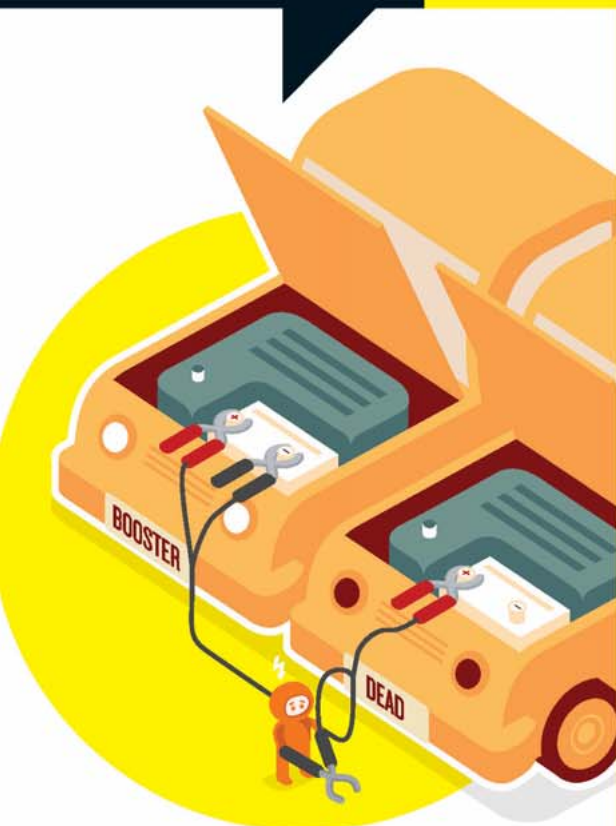
- A. Drywall rasp
- B. Carbon-steel wire cup brush
- C. General-purpose mill file
- D. Ceramic and marble file



what to do?

17. Your truck is dead in the driveway and needs a jump. So you hook the red cable to the positive terminal of the dead car, repeat for the booster, then connect the black cable to the negative terminal of the booster battery. Where should the final black wire's clamp be connected?

- **A.** Dead battery's negative terminal — **B.** Dead vehicle's engine block — **C.** Dead battery's positive terminal — **D.** Leave it loose for good luck

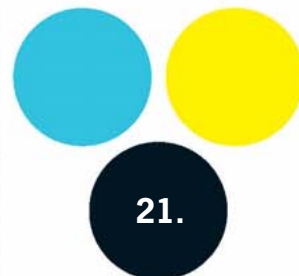


18. The neighborhood tetherball league is gearing up for a new season, and this year you want to build a home pole to practice in private. You're digging a hole for a 4 x 4 post that will rise 8 feet above grade, set in ready-to-mix concrete. The 4 x 4 is 12 feet long. How deep and wide should the post's hole be?

- **A.** 4 feet deep, 1 foot wide — **B.** 4 feet deep, 4 inches wide — **C.** 2 feet deep, 6 inches wide — **D.** Just dig until you're tired

19. Clearly, the lumberyard is out to cheat you. The measurement listed on your boards isn't the same as the dimensions you find by putting a tape measure to each stick. A 2 x 4, for example, measures as 1.5 x 3.5 inches—the big numbers are "nominal" dimensions, the sawyers say. So if you're at this shady lumberyard buying a nominal 2 x 8, how big is that board in reality?

- **A.** 2 x 8 — **B.** 1.5 x 7.5 — **C.** 1.5 x 3.14159265 — **D.** 1.5 x 7.25



You've been putting off the chore long enough—today's the day you finally buckle down and build your potato cannon. After cutting the PVC pieces to size and cleaning the ends you plan to join, what's the next step?

- **A.** Apply purple primer to the male end and PVC cement on top of that. Wait 5 minutes, repeat for the female end, then fit them together — **B.** Dry-fit the pieces and fire a test potato — **C.** Brush primer onto the inner rim of the female end and the outer rim of the male end. Apply PVC cement on top of the primer. Fit the ends together immediately — **D.** Apply purple primer to each end, wipe it off, slather PVC cement to the ends, wipe it off, and then fit each piece together

20. After shaping the edges of soft, nonferrous metals, the teeth on your single-cut file become clogged with metal shavings, prohibiting a smooth finish. The tool you use to clear out the file's teeth and keep it cutting properly is called a:

- **A.** File card — **B.** File pick — **C.** File driver — **D.** File solution



what's that?

22. Conversing with the gentlemen at your local back-street drag race, you claim that your modified Corvette's supercharger is superior to a rival's Nissan GT-R turbocharger. What's the difference between a supercharger and a turbo?

- A. There is no difference
- B. Superchargers produce more power
- C. Exhaust gases drive a turbo; superchargers run off the crank, like alternators
- D. Only superchargers use ultracool air from the climate-control system

23. After years of yanking loose branches from the yard's treetops with a frayed extension cord, you've learned that you may be using the tool unsafely—especially when it's also plugged in. According to the National Fire Protection Association, which of the following is an appropriate use of an extension cord?

- A. As permanent wiring concealed under floors or behind walls
- B. As wire tied to an overhead pipe in the basement shop
- C. As a power source for a toaster, heater, coffeepot or any other electric heating appliance
- D. As 120-volt service through a grounded three-prong outlet to power a non-heat-producing appliance

25. Your shop wouldn't be complete without this automotive tool, which can separate the ball joints, tie rods or pitman arms from a suspension upright (aka the knuckle). What is the tool's name?

- A. Pickle fork
- B. Sausage fork
- C. Onion fork
- D. Bacon fork



26. If this wall is load-bearing, which way does it run in relation to the direction of the joists?

- A. Perpendicular
- B. Parallel
- C. Backwards
- D. There's no hard-and-fast rule

27. A pair of white wires dangles from this installed outlet. What connection is broken?

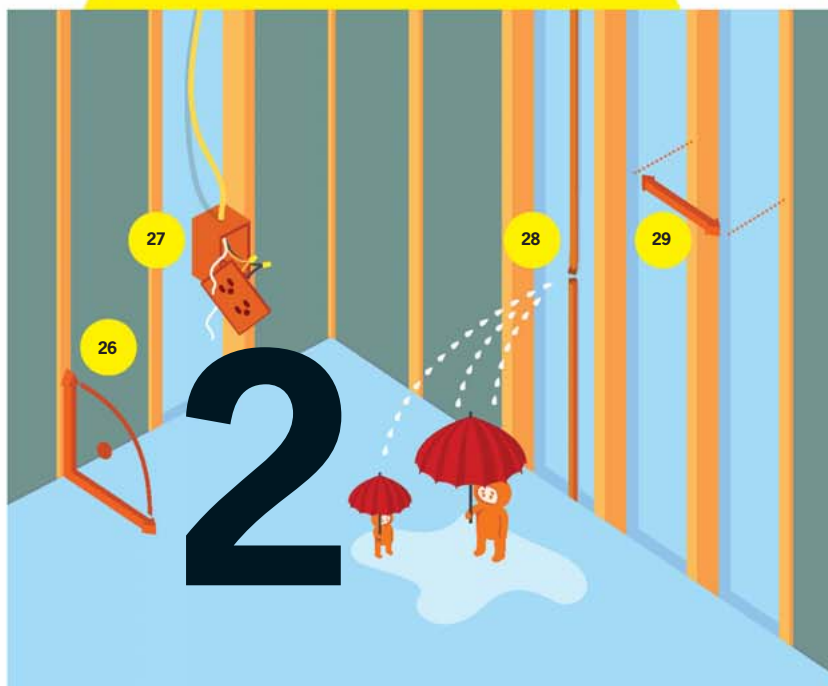
- A. Hot wire
- B. Neutral wire
- C. Ground wire
- D. Tripwire

28. When installing a medicine cabinet, you went a little wild with the Sawzall and cut this pipe. What type of fitting can reconnect it?

- A. Bushing
- B. Adapter
- C. Coupling
- D. Flange

29. What is the typical distance on-center between studs?

- A. 12 inches
- B. 16 inches
- C. 24 inches
- D. One pace



24.

You love relaxing at Jiffy Lube, but fear you're wearing out your welcome. Maybe you're overdoing the oil changes. How often should you replace old oil?

- A. Every 3000 miles
- B. Every 5000 miles
- C. Every 7500 miles
- D. As often as the owner's manual says

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what's that?



30. Your old house's walls are out of square, making this woodworking tool—which can measure, copy and mark any angle—an indispensable gauge. Every craftsman owns one, but rarely will two identify it by the same name. Whatchamacallit?

- A. Sliding bevel square — B. T-bevel — C. Adjustable bevel square — D. All of the above

31. Your serpentine belt's looking rough, and any day now you expect to find it lying detached in the driveway. How do you know when it's time to replace a serpentine belt that's grown long in the tooth?

- A. Replace it when you change your oil
— B. Change it when you rotate your tires
— C. Replace it when the surface scales and it begins to fray
— D. A decent serpentine belt should last forever

32. You're trying to learn the names of your ramshackle Victorian's fancy carvings so you can navigate the millwork catalog without just tracing the profile and hoping you order the right replica piece. Last time, corbels came instead of crown molding. Which of the following is *not* the name of an actual house part?

- A. Mullion
— B. Tympanum
— C. Festoon
— D. Nasturtium

35. You and your beloved circular saw have been through thick and thin ... lumber. But which material can *not* be cut using a circular saw fitted with a wood-cutting blade?

- A. PVC molding
— B. Oriented-strand board
— C. Medium-density fiberboard
— D. Fiber-cement siding

36. You're modifying a scrap 2 x 4 to replace a rotten deck-rail spindle. Cutting the lumber with handsaws, you're tackling its long edge before trimming to length. In the correct order, which two saws do you need?

- A. Crosscut saw, ripsaw
— B. Hacksaw, ripsaw
— C. Ripsaw, chain saw
— D. Ripsaw, crosscut saw

37. After struggling to remove a tire, you want to make the nuts easier to turn next time. What tool turns lug nuts to the ideal tightness when mounting a tire?

- A. Pneumatic wrench
— B. Breaker bar
— C. Torque wrench
— D. Tire iron

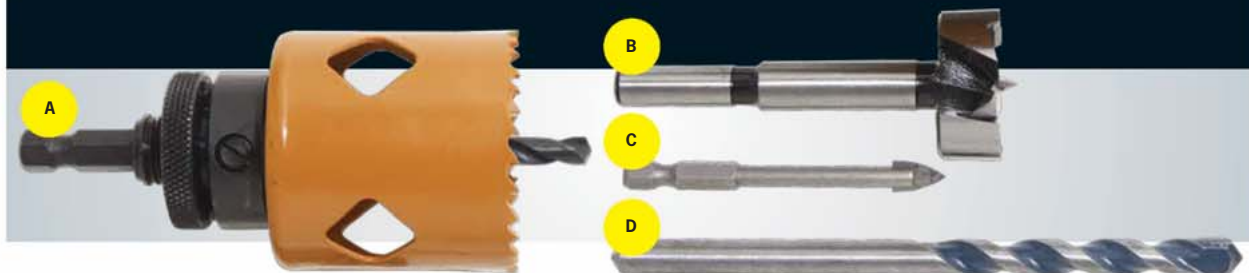
33.

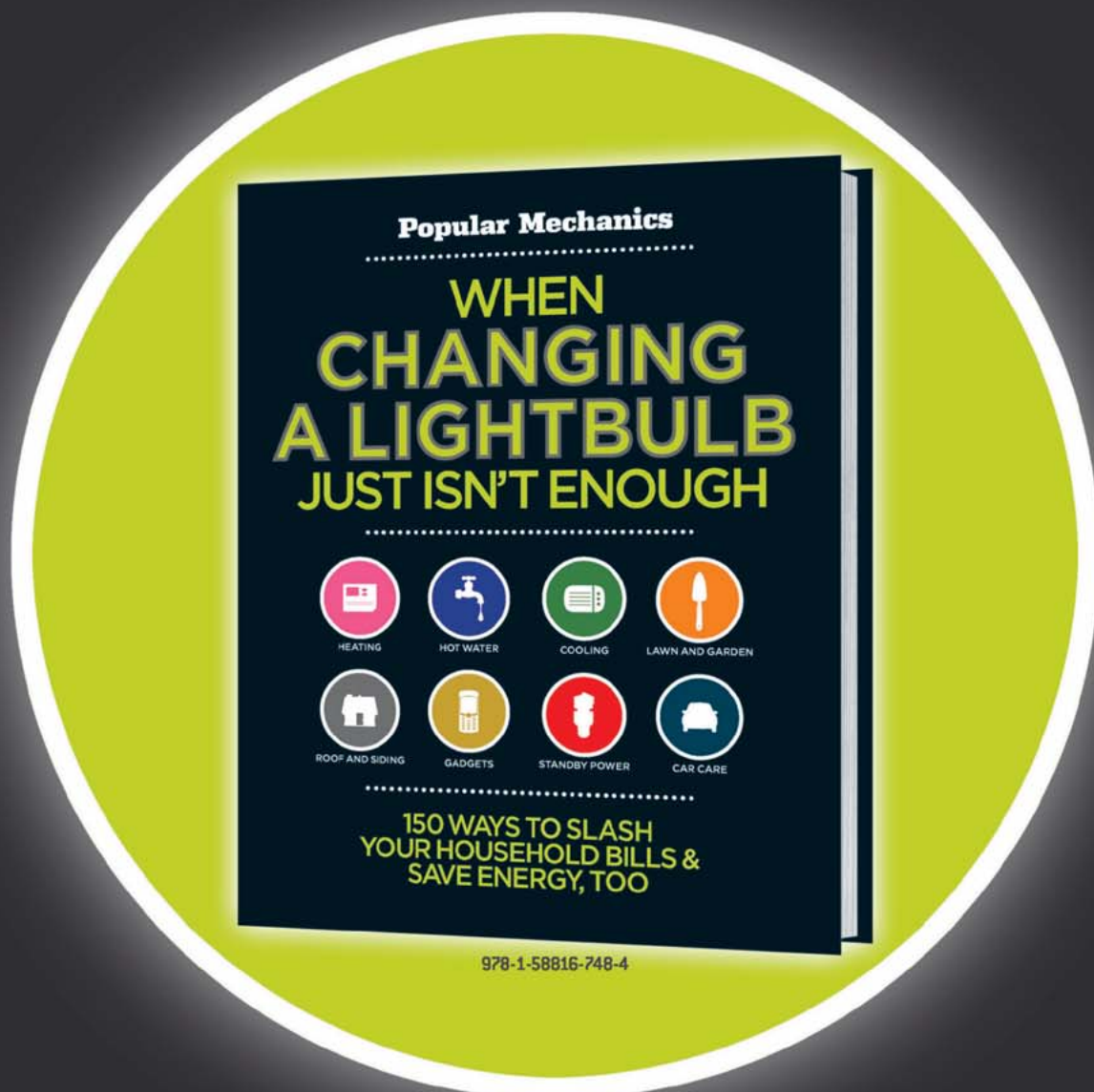
It's tough to remove a roll pin that has rusted in place over the years. These pins lock gears and levers to a shaft such as a clutch cable arm. To get a stubborn one to budge from its position, you should:

- A. Use a roll-pin punch nearly as big as the pin
— B. Drill it with a high-speed-steel bit the same size as the pin
— C. Use a roll-pin punch about half the pin's diameter
— D. Lube it in WD-40 and extract it with a rare-earth magnet

34. These bits put holes in brick, glass, metal and wood—but only one of these, sized 1½ inch in diameter, is the perfect tool to install invisible European Soss-style hinges on cabinet doors. Which bit is it?

- A. Bimetal hole saw — B. Forstner bit — C. Carbide-tip bit — D. Masonry bit





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TEST YOUR DIY IQ ANSWERS

1. D Concrete doesn't dry—it cures via a chemical reaction between cement and water. The reaction takes place over five to seven days, during which time it's critical to keep the fresh pour covered and moist. Stake a tarp over the patio and mist the slab once every 24 hours.

2. B Air pressure recommendations appear on the driver's side doorsill or in the owners' manual, not here. The only psi number on the tire is the *maximum* air pressure—not a *recommended* level.

3. D Second step down from the cap.

4. D Increasing the tire pressure reduces the rolling resistance. Going easy on the gas provides an efficient throttle input. And a/c requires engine power to run, reducing fuel economy.

5. D Hacking at an old gutter with a moving reciprocating-saw blade just might knock you off a ladder. Instead, wedge the saw's blade and shoe firmly against the material before pulling the trigger. Get the other saws' blades spinning at full speed before carefully making contact with the workpiece.

6. B Window sash-weight chains' flexible links and low heft make them ideal to snake wires down stud bays.

7. C Polyurethane insulation materials typically have an R-value of about 7.0 to 8.0 per inch, and rigid polyurethane panels with foil facings can get up to 8.7 per inch. With an R-value of 3.0 to 3.8, loose-fill cellulose ranks near fiberglass batts. Same goes for shredded blue jeans, with a 3.4 to 3.7 R-value, and for mineral wool, about 3.7.

8. B Ball-peen hammer. The ball-peen—and not your old carpenter's framing hammer—is appropriate for striking chisels, punches and other hardened metal. Use softer faces like lead or brass for delicate work.

9. C Hickory is the hardest here, falling in at 1820 on the Janka hardness scale. Cherry is at 950, bamboo measures 1380, and maple scores 1450.

10. A The 15-degree nozzle's narrow spray can cut caked mud off the lawnmower and strip weak paint from brick. The wider, gentler, 60-degree spray can apply mixtures of cleaning chemicals and water to weathered decks and wood siding.

11. C Acrylic paints are superior to alkyds—except on exterior ironwork. Scrape away loose paint and rust, apply a fish-oil-based primer, and clean with mineral spirits.

12. C Overdoing mulch actually stresses the plant—pile it 2 to 4 inches high, and avoid burying the plant's root stem. Apply mulch in cool late spring to give the plant's roots insulation against the first hot sunshine.

13. B The problem with those cheap lug wrenches is that the short handle gives the user little leverage. The pipe extends the handle and increases the user's mechanical advantage over the nut the wrench is turning.

14. B Carbon-steel brushes like this one work on ferrous metals, but can introduce rust and contamination to stainless steel.

15. C At up to 11.3 cfm at 90 psi, the orbital sander's continuous draw may overtax this machine during extended periods of use. The compressor can handle the 3/4-inch impact wrench (2.5 to 3.5 cfm at 90 psi), the framing nailer (2.2 to 5.0 cfm at 90 psi) and brad nailers (0.3 cfm to 1.3 cfm at 90 psi).

16. C Dutchman repairs often stand in contrast to the surrounding flooring, and on historic floors exposed to years of wear, it's not uncommon to see several such patches. The aesthetic is so distinct that some engineered flooring manufacturers have built faux Dutchman repairs into the finished product when replicating historic styles.

17. B Connect one end of the positive (red) cable to the positive (+) terminal on the battery of the dead car, then repeat for the booster car. Connect one end of the negative (black) cable to the negative (-) terminal on the booster battery. Then connect the other end of the negative (black) cable to a clean, unpainted metal surface (such as the engine block) on the engine of the disabled vehicle.

18. A According to Quikrete's *Build and Repair With Concrete* (the edition with a sneering, troweling Don Knotts on the cover), the diameter of a

posthole should be roughly three times the post diameter. Hole depth should be one-third the overall post length. Ergo, drop this 12-foot 4 x 4 in a hole 1 foot wide and 4 feet deep, leaving 8 feet of tether post exposed.

19. D The 8-inch nominal dimension actually measures at 7 1/4 inches. The difference occurs because the nominal dimensions typically refer to rough lumber, the size of which declines as the boards are planed and dried.

20. A File card.

21. C The cement will begin setting immediately, so have each end primed and ready before beginning the cement slather. PVC is easy to glue—no flame, no flux—but don't dawdle.

22. C Both the turbo- and supercharger are pumps that force more air into the engine. Increased air adds oxygen to the intake charge, producing more power. Turbos have a compressor and turbine wheel connected by a shaft—the exhaust gases spin the turbine, which drives the compressor. Superchargers, however, have only a compressor, which is powered by some connection to the crank, usually a belt.

23. D Not only are choices A through C off-limits, but if that outlet doesn't have the third grounding connection, code states that you can't even grind off the cord's third prong. Install a new outlet. And use rope to wrangle dead wood.

24. D Modern engines typically outlast the rest of the car as long as the manufacturer's service schedule is followed. So do what the book says, but remember: Commuting in stop-and-go traffic is considered "severe" duty.

25. A The pickle fork's forged tines will separate the tie rod ends from the suspension, either by hammering the handle or attaching the handle to an air hammer.

26. A Load-bearing walls in the central part of the house run perpendicular to the joists. Exterior walls and most stair walls are also load-bearing.

27. B Neutral wires are white.

28. C Couplings continue a straight run in pipe or tubing, joining pipes of like sizes or, with a reducer coupling, mating two different diameters.

29. B Sixteen inches.

30. D The multi-monikered hand tool is critical when installing interior trim. Measure the angle between two walls by pressing each leg against the wall surfaces, lock in the setting, then transcribe the findings to the miter saw and cut the trim.

31. C Depending on the belt, the signs of old age include surface cracking—think of the surface of a dry lakebed—and fraying like an unraveling sweater. Modern serpentine belts should last 10 years and 100,000 miles.

32. D The mullion is a vertical member separating two casement windows, the tympanum is the recessed triangular face of a pediment, the festoon is a decorative fruit or floral carving often found on a frieze, and the nasturtium is an edible flower.

33. A Using a roll-pin punch that's too small will flare the end of the pin and make it even harder to move. The metal in the pin is so hard that it'll only melt the drill bit. The right punch is nearly as big as the pin. With the punch's dimpled end centered on the pin, smack the tool smartly with a ball-peen hammer to drive the roll pin out.

34. B For Soss hinges, use a Forstner sized 1 1/8 inch, or 35 mm.

35. D The blade to cut fiber cement has a tooth geometry unlike the serrated edge of a woodcutting blade. Instead, it only contains about four or five teeth, often made of a high-density carbide and capped with a nonstick coating. Woodcutting blades are perfect for OSB and MDF, and they're passable for PVC.

36. D Ripsaws work like a series of chisels to scoop out material in line with the woodgrain. Crosscut saws sever the wood fibers at each edge of the blade, then the saw teeth scoop out the sawdust in the saw blade's channel, or kerf. On a 2 x 4, the crosscut saw works across the short side, while the ripsaw cuts along the board's length.

37. C Tightening the lug nut fractionally, with a torque wrench, lengthens the wheel stud. This maintains the proper clamp force on the wheel. Overtighten the nut (likely with a pneumatic wrench) and you risk exceeding the bolt's yield point, which weakens the metal. Too loose, and the wheel could fall off. **PM**

MAKE THE GRADE

If you correctly answered ... then you are:

- 1 to 9** Dangerous with a drill
- 10 to 18** Flirting with competence
- 19 to 27** Able to work unsupervised
- 28 to 36** Admirably handy
- 37** Ready for Wrench Mensa



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super tugs

By Carl Hoffman

When giant tankers need guidance getting in and out of port, captains call on the world's most

The *Methane Princess* is inbound, and she's not to be trifled with. She's 909 feet long and 142 feet wide, draws 33 feet and is loaded with liquefied natural gas (LNG). The 94,000-ton vessel is perceived as a giant floating bomb, and at slow speeds, within the confines of crowded shipping channels and ports, there's simply not enough water passing over her rudder to maintain steerage. She might as well be adrift. Which is why, on this muggy, overcast September afternoon, the tractor tugboat *Edward J. Moran* is





powerful tugs to steer them straight.

Photographs by Ed Keating

In a mismatched tango, a tug prepares to escort the *Methane Princess* down the Savannah River and out to sea.

churning down the Savannah River, headed 8 miles into the Atlantic off the Georgia coast to meet the *Princess* and escort her to the Elba Island LNG terminal, 5 miles east of Savannah. And why the *Edward* and her sister ship *Bulldog*, owned by another company and heading out with us, are tasked with the job: They are the most powerful, sophisticated tugs in the United States. “She’s got the strength of a center in the NFL,” David Missroon, the *Edward*’s captain, says of his vessel, “with the speed and agility of a defensive end.”

Up in the pilothouse, Missroon is sitting in a Kirk-like *Star Trek* chair, each forearm resting on a console, each hand holding a fist-size joystick knob. Missroon flicks his wrists. The ship pitches forward—the force is strong enough to send me to the deck, but I’m holding on with both hands. Almost as quickly, the tug comes to a dead stop and then lurches backward. I’ve been around the water my whole life, and I’ve never seen a vessel move the way the *Edward* moves, much less one 98 feet long and packing 6500 hp: She can go from 13 knots forward to 13 knots in reverse in 15 seconds. Another twist of the joysticks and the ship pivots 360 degrees within her own length.

The reason for all this power and agility is simple. To convince a skittish public of the safety of transporting LNG, the Coast Guard and the LNG industry are building a fleet of tugs that are able to maintain absolute control over the tankers in port at all times.

When we exit the river and head into the ocean, the swells pick up, and 6-foot waves, driven by winds gusting to 30 knots, crash over the pilothouse. It’s a long, rough slog out to the *Princess*, which finally looms into view—a British-registered, black-hulled steel monolith that left Egypt 12 days ago.

We slide up against the hull in the ship’s lee, and Rodney Magwood, the docking pilot, climbs the gangway and disappears inside the tanker. We maneuver to the stern, the bow hard against steel, and deckhand David Krokoski tosses up a light line connected to our tow rope, a 9½-inch braid of Kevlar with a million pounds of breaking strength. We ease back 200 feet into what’s known as the in-line position and match the *Princess*’s speed of 9 knots. From here on, the tanker will remain tethered until she’s back out at sea.

It takes 2 hours for the *Edward* to reach the river’s mouth. The tug has four crewmen: a captain, a mate, a deckhand and an engineer, and they work a week on and a week off, on standby 24 hours a day for LNG work and whatever else the port throws their way, from docking container ships to rescuing disabled vessels at sea. Missroon is a third-generation Savannah River tug sailor. His mate, Anthony Groover, 25, is the son of a docking pilot who was trained by Missroon’s father and who in turn trained Missroon. “When I was a kid, I spent nights on the tugboat with my father,” Missroon says, “and my life has mirrored his. He wanted me to go to the University of Georgia, but he died in a car



water power

For nearly 200 years tugboats have butted, towed and nudged big ships in American harbors. But handling the current maritime fleet of mammoth vessels calls for greater speed, agility, safety and power. Here’s the hardware that gets the job done.

accident when I was a senior in high school. I changed my plans and came to the water.” He adjusts the volume of a John Mellencamp song playing on the radio. “My son wants to do the same. He’s spent lots of time on the boat, and it’s in his blood, just like me.”

It’s late afternoon when the *Edward* and the *Princess*, now under escort by a U.S. Coast Guard helicopter and two Coast Guard rigid-hull inflatable boats, close in on the LNG terminal, a long concrete pier parallel to the shore. These terminals have long been controversial, but all LNG tankers are double-hulled, and during 33,000 voyages over the past 30 years there have been only eight leaks—none of them resulting in fires. LNG won’t burn unless it becomes a vapor and dissolves into the air at a concentration of 5 to 15 percent. The worst accident occurred in 1944 in Cleveland at the world’s first commercial LNG plant, when a tank failed and spilled its entire contents into creeks and sewers. When the air-gas concentrations were right, the vapor caught fire, killing 128 and injuring 225. Since then there have been four accidents worldwide that resulted in fatalities, all at plants. “We don’t want any chain in the process to be weak,” says David Beardsley, vice president of construction and repair for Moran.

We’re traveling at 9 knots, and it’s time to slow down. From here on, Magwood, the docking pilot on the *Princess*’s bridge, calls the shots. “Half ahead, transverse,” he says over the radio.

“Half ahead,” replies Groover, now at the *Edward*’s con, as he pivots the joysticks inward, rotating the screws so they’re facing away from each other, a maneuver that acts as a brake and is known as a transverse arrest. The *Edward* shudders violently—it feels as though we’re bumping over a washboard dirt road. The meter registering the load on the *Edward*’s line shows 54 tons. The *Edward* slows to 8 knots, as the *Bulldog* swings round to the *Princess*’s bow. At 7 knots, Groover shifts to starboard. When the *Edward*, straining and digging, slowly pulls the *Methane Princess*’s stern around, 94 tons register on the line.

“Five-point-eight and backing,” Groover says.

The *Edward*’s bow is pushed down, its stern lifted up; it shudders as it backs against the strain.

Bit by bit over the next half-hour, we slow the *Princess* down to 4 knots. Two more tugs join us, the *Bulldog* “end on”—bow forward and perpendicular to the



2

The Engine

Twin 12-cylinder diesels with 710 cubic inches per cylinder generate 6500 hp—almost twice that of a standard tug.

3

The Winch

It can generate 100 hp—enough to pull the tugboat forward even when the engine is full astern.

1

Swiveling Twin Propellers

Twin screws known as Z-drives extend from the bottom of the hull like room fans and rotate 360 degrees, enabling tugs to go from a top speed of 14 knots to zero within a boatlength and to move forward while turned sideways.

4

Fire-Suppression System

To douse fires, the *Edward J. Moran*, pictured here, calls on the most powerful firefighting capacity afloat. Twin 900-hp pumps pull water through 12-inch risers to a pair of 360-degree nozzles that the crew controls remotely from the pilothouse. The flow rate: 11,800 gallons of water per minute.



ship—against the *Princess's* bow and two older Moran tugs amidships. The berth is now about 100 yards ahead. As Magwood guides the behemoth in, a dance based on years of experience and intuitive knowledge between docking pilot and tugs commences. “*Edward*, take me on down again,” Magwood says.

“Roger, take you down,” Groover says.

“Easy, *Dog*, easy,” Magwood says.

Over the next 45 minutes, the closer we get to the dock, the faster the commands come.

“Easy does it on the *Edward*,” Magwood says. “Thirty percent on the *Dog*. Easy on the stern tugs,

easy.” The process is precise and slow, a nudge here, a pull there, four tugs and the *Princess*—four captains and docking pilots, five individual powerplants—all working in concert.

“Stronger stern tugs, stronger,” Magwood commands. “Easy astern, easy. Stop, *Edward*. In position.”

Groover smiles. “We just put it within 1 foot of where he wanted it. Hey, Rodney, nice job!”

When the *Princess* is safely tied up, the *Edward* and the *Bulldog* lie a few hundred feet away; they stand by for the next 24 hours of unloading. The two older tugs return to Moran’s dock in downtown Savannah. John



Deckhand David Krokoski signals from the tugboat *Edward J. Moran* while crewmen from the tanker *Methane Princess* prepare the gangplank for offloading the docking pilot. Opposite: David Missroon, captain of the *Edward*, controls 6500 hp with the toggles in his hands.



Johnson emerges from the engine room, and the smell of his homemade enchiladas soon fills the galley below the pilothouse. The galley is better equipped than my kitchen at home, with a full-size stainless-steel fridge and oven. “We all love to cook,” first mate Groover says. “Nothing comes out of a box.”

Out here on the water, as the sun dips below the river’s green banks, it’s easy to see why generations of men have plied the tugboat trade. The river is serene, ever-changing. The crewmen are removed from the world but also connected to it in a way merchant seamen in the open ocean never are. With such small crews, even deckhands get a chance at every job. And though they’re on board for a week at a time, they remain in home port, and modern conveniences make the job less lonely—cellphones connect to friends and family, and flat-screen TVs in the galley and cabins and Wi-Fi keep the world at hand.

Late the next afternoon, it’s hot, bright and blue, and the *Princess* is empty, ready to disembark. The *Bulldog* noses into the tanker’s starboard bow and ties on. The *Edward* latches to her stern behind 267 feet of line, and another Moran tug ties on amidships.

“Easy on the *Dog*,” calls Magwood, once again directing from the bridge of the *Princess*. The *Bulldog* responds with one long whistle and three short. Before two-way radios, tugs and pilots communicated by whistle; most captains still prefer it. One whistle acknowledges the request, three whistles means easy, and four means hooked up, slang for full ahead or astern.

“Stop, *Dog*, stop.”

One whistle.

“Straight out on *Edward*, straight out. Stop the *Dog*, stop. All stop.”

The *Edward*’s engines throb, the river churns and foams, and the rope strains. The *Methane Princess*

begins to slide away from the terminal and into the channel at the stately speed of 1 knot. The tanker is the length of a city block, and such an enormous mass has an inertia that is hard to grasp, yet the tugboats move it with choreographed precision and few words.

We drift backward a bit, and Magwood calls, “Stronger, *Edward*, stronger.”

One long whistle, two short.

“Okay, right on up the river, *Edward*. Easy, easy, *Dog*, easy!”

We power backward. The *Bulldog* pushes on the bow, and the *Edward* navigates to almost 90 degrees astern of the *Princess*, shuddering and thrumming and vibrating. The *Edward*’s bow digs into the river, and the stern tilts up, swinging the tanker around, slowly, slowly, until she’s pointing downriver.

“Stop, *Edward*, stop.”

A churning swirl of water begins under the stern of the *Princess* as she goes to full ahead. “*Edward*, full ahead, and home we go!”

It’s night by the time we drop off the *Princess* 8 miles out, pick up the pilot Magwood and re-enter the river. A high, full moon lights a shimmering path over the water. It’s quiet and dark in the pilothouse, the glow of gauges and computer screens soft and comforting in a cocoon of utility and purpose that’s removed from the traffic and lights and restaurants of pulsing Savannah, so near but so apart.

In the anonymity of darkness, the stories of men who work 24 hours a day, 7 days a week, to keep it all going unspool. Of pressing and holding steel container ships and tankers to the docks in hurricanes and 60-knot winds. Of times in waves and winds when tugs had to venture out to sea to find disabled ships and bring them safely to port. Of the pride of sons joining their fathers on the water to do gratifying work that’s about steel and horsepower amid dynamic waves and currents and wind. Of shared experience and no nagging existential angst about why are we here and what are we doing.

The ship thrums under our feet. It’s 10 pm, the dock is near, and the lights of Savannah burn bright, lighting up the horizon. The men on the *Edward* are like those in coal mines and on deep-sea oil rigs—they’re the wizards of Oz, the men behind the curtain, unseen and unheard for the most part, but vital to everything we take for granted.

Before we bump gently against Moran’s dock in the moist night, Groover and Krokoski are throwing lines and spraying down. As I step off the tug, I hear whistles tooting somewhere out there, over the river. One long, three short. An answer. Now I know what they mean, and they’ll be singing all night long.

PM



OLYMPIC SCIENCE

■ WINTER EDITION

THE 2010 WINTER OLYMPICS IN VANCOUVER, BRITISH COLUMBIA, ARE HERE. AND FOR THE ATHLETES, MEDALING REQUIRES A FINELY TUNED COMBINATION OF HIGH-TECH EQUIPMENT, INTENSE TRAINING AND THE ABILITY TO HARNESS COMPLEX PHYSICS AND BIOMECHANICS.

by
DAVIN
COBURN

Ted Ligety,
2006 U.S. Olympic
gold medalist,
alpine combined event



INSIDE
ALPINE SKIING
ICE HOCKEY
BIATHLON
FIGURE SKATING
CURLING
SKI JUMPING
BOBSLED

POPULARMECHANICS.COM
MARCH 2010

81

ALPINE SKIING Carving Turns at 50 mph

OLYMPIC SKIERS SUBJECT THEIR BODIES to as much as 3.5 g's—more than space shuttle astronauts endure during launch—and to velocities that would earn them speeding tickets in most states. And when steep sections of a run flatten out, it takes a world-class athlete to stay upright despite the downward inertia. “A lot of us can leg-press 900 pounds, but that’s easy compared to this race,” says Ted Ligety, a Park City, Utah, native and reigning Olympic gold medalist in the combined skiing event, which is based on the total time from one downhill and two slalom runs.

For the 2010 Olympics, Ligety is focusing on the slalom and giant slalom events. The slalom course is 2507 feet long, with 65 gates and a vertical drop of 722 feet. The giant slalom event has about 10 fewer gates in a course of more than twice the length (5256 feet) and vertical drop (1476 feet). Both events demand that athletes master a high-speed onslaught of gravity, friction and inertia.

■ **SKIS**
Ligety’s Rossignols are made of a wood, fiberglass and metal laminate. Shorter skis enable competitors to make quicker turns; longer skis generate more speed. Minimum lengths: 165 cm for the turn-filled slalom; 185 cm for the giant slalom.

■ **KNEES**
Alpine skiers’ knees sustain about 110 ft-lb of lateral torque during turns and nearly 300 pounds of total force at the joint—almost as much torque as can be found in the engines of a ski resort’s snow-removal trucks.

■ **TURNS**
Skiers generate enough g’s in turns to make a 180-pound athlete—like Ligety—feel like he weighs more than 600 pounds. Steep angulation of the legs and an upright torso generate greater energy and speed coming out of the gates.

■ **THE COURSE**
For the men’s giant slalom, the gradient peaks at nearly 40 degrees on the Dave Murray Downhill Course at Whistler Mountain (above). Skiers carve blind turns at 50 mph and fly down straightaways at up to 90 mph.



■ ICE HOCKEY Firing Pucks at 100 mph

WHEN A PLAYER BLASTS a slap shot 30 feet from the net with 125 pounds of force, the goalie has less than 200 milliseconds to react to the flying 3-inch-wide, 1-inch-thick puck. "The physics of it are astounding—even to me," says U.S. team hopeful David Backes, a forward on the St. Louis Blues.

■ **BACKSWING**
At the height of the windup, the player's hands are 15 to 23 inches

apart, and the chest, shoulder and arm muscles are stretched and ready to contract.

■ **PRELOADING**
Milliseconds before the blade hits the puck, it scrapes the ice about a foot behind the hard rubber disk. The stick bends up to 30 degrees, which preloads it like a spring, providing 50 percent of the shot's velocity.

■ **CONTACT**
Preloading also extends the length of time the blade is in contact with the puck, which increases the shot's acceleration. For elite players, contact can last 40 ms. In baseball, bat-on-ball impact lasts less than 1 ms.

■ **STICK**
Personal preference dictates whether a stick is made of wood, Kevlar, graphite, carbon fiber or aluminum. Backes uses a composite model that bends low on the shaft, giving him a quicker shot release.

■ **ONE-TIMERS**
When players shoot a moving puck, they tap into that existing velocity and add a few mph to their own shot.

David Backes, forward, St. Louis Blues, U.S. Olympic team hopeful

Preloading

■ BIATHLON Rifle Shooting at 170 bpm

COMPETING IN THE BIATHLON requires both endurance and world-class shooting skills. Athletes must ski 20 kilometers with a rifle and stop four times to shoot at targets, alternating prone and standing positions. The .22-caliber rifles have no optical sights, and missing a target can mean skiing a 150-meter penalty loop. Former U.S. team member Shaun Marshall-Pryde once compared the event to "climbing 25 flights of stairs and then threading a needle five times without missing the hole." Success requires tremendous conditioning: Within seconds of arriving at the ranges, athletes must bring their heart rate down by about 20 beats per minute in order to shoot with a steady hand.



20-km Event Order: Ski 4 km → → Prone Shooting → → Ski

■ FIGURE SKATING Spinning Gracefully at 420 rpm

A DEMONSTRATION OF POWER AND GRACE, this event may be scored at the whim of judges, but it is governed by irrefutable laws of physics.

"Girls did triple axels, then triple-triple combinations, and in the future they'll definitely be doing quads."

— Rachael Flatt,
U.S. Olympic hopeful

■ LAUNCH

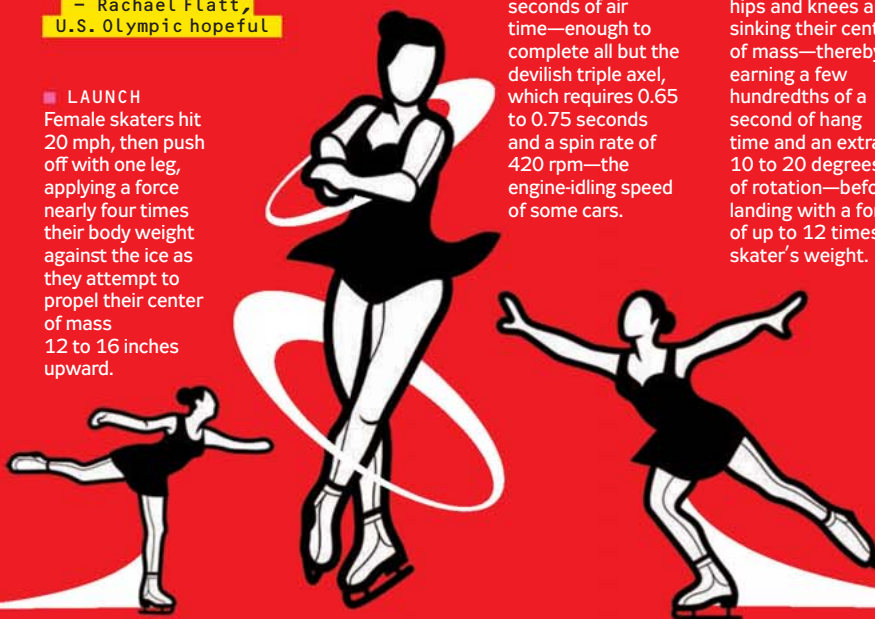
Female skaters hit 20 mph, then push off with one leg, applying a force nearly four times their body weight against the ice as they attempt to propel their center of mass 12 to 16 inches upward.

■ FLIGHT

A 45-degree jump gives skaters 0.55 seconds of air time—enough to complete all but the devilish triple axel, which requires 0.65 to 0.75 seconds and a spin rate of 420 rpm—the engine-idling speed of some cars.

■ LANDING

Skaters tweak tight landings by flexing hips and knees and sinking their center of mass—thereby earning a few hundredths of a second of hang time and an extra 10 to 20 degrees of rotation—before landing with a force of up to 12 times a skater's weight.



Most Olympic biathletes use a modified 8.8-pound Anschütz 1827 Fortner rifle.



■ HEART RATE

The skiing portion of the biathlon brings an athlete's heart rate up to 190 beats per minute. The target heart rate when shooting: 170 beats per minute.

■ RIFLE

The rifle's straight pull bolt is opened with the index finger and closed with the thumb. The shooter never has to change position—and can pull his five shots in 20 seconds or less.

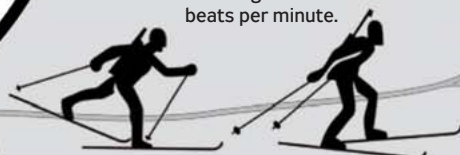
vibration and is more accurate," says Jack Sutton of Hart Rifle Barrels.

■ STOCK

American Olympian Tim Burke traded his rifle's original walnut stock for one made by a German woodworker. "The rifles are so individualized, you couldn't compete with a teammate's," he says.

■ WEIGHT

Rifles must weigh at least 3.5 kilograms (about 7.7 pounds). "A heavier barrel is harder to ski with, but has less



km → → Standing Shooting → → Ski 4 km → → Prone Shooting → → Ski 4 km → → Standing Shooting → → Ski 4 km

✖ MISS A SHOT? Choose between skiing a 150-meter penalty loop or adding 1 minute to the time.

■ CURLING Sliding 42 Pounds of Granite

MORE THAN JUST SHUFFLEBOARD ON ICE, curling is also one of the fastest-growing Winter Olympic sports in the U.S., and a marvel of physics.

In curling, teams slide 42-pound granite stones down an ice sheet toward a target. On dry surfaces, the front of a spinning sphere generates more friction than the back, and the sphere veers in a direction different from that of the rotational vector. On ice, the opposite is true: A liquid layer reduces frontward friction, and the stone spins and slides in the same direction. This is where the sweepers get involved. Two players use brooms to scrub the ice ahead of the stone, enhancing the liquid film in order to adjust curl (how much the stone veers to either side) and the length. The U.S. squad's tests have shown that sweepers can "drag" a stone up to 16 extra feet.

Every ice surface plays slightly differently, and even the crowd at Vancouver's new 5600-seat curling arena will affect shots. "When it's packed, there will be more heat in the building, and the ice could get softer and slower."

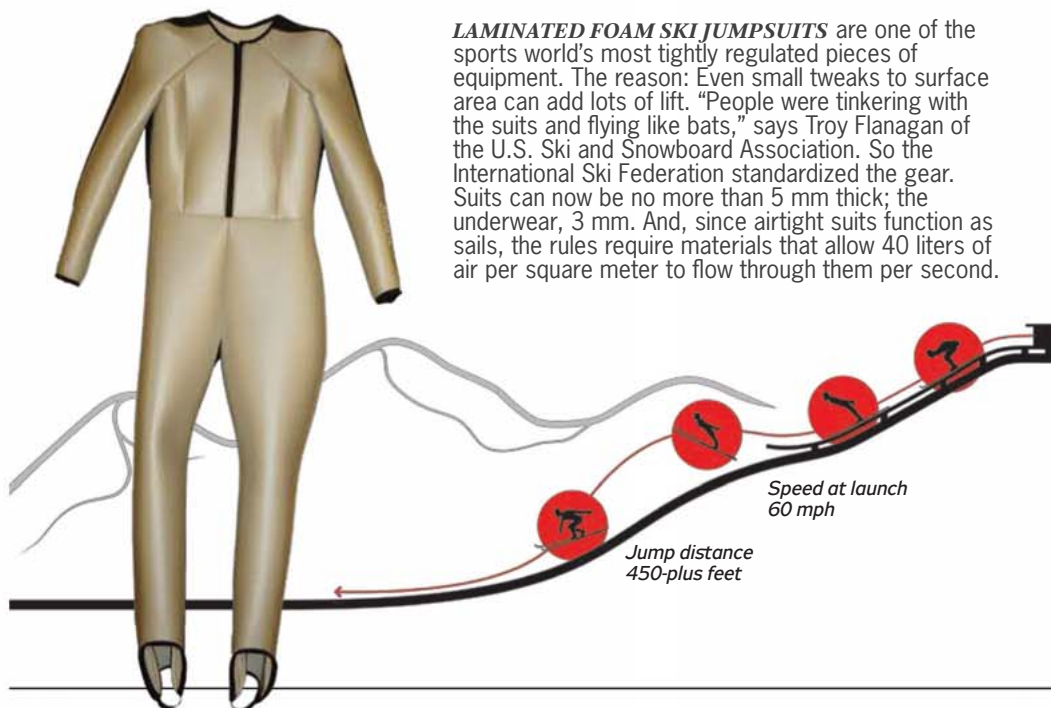
— Phill Drobnick,
U.S. Men's coach

■ ICE SURFACE
Unlike the smooth surface used for skating, curling ice is dimpled with tiny drops of frozen water—or "pebbles"—that create friction with the stone and cause it to curl.



■ SKI JUMPING Flying 450 Feet

LAMINATED FOAM SKI JUMPSUITS are one of the sports world's most tightly regulated pieces of equipment. The reason: Even small tweaks to surface area can add lots of lift. "People were tinkering with the suits and flying like bats," says Troy Flanagan of the U.S. Ski and Snowboard Association. So the International Ski Federation standardized the gear. Suits can now be no more than 5 mm thick; the underwear, 3 mm. And, since airtight suits function as sails, the rules require materials that allow 40 liters of air per square meter to flow through them per second.



■ BOBSLED Banking Turns at 95 mph

IN 1992, FORMER DAYTONA 500 CHAMPION Geoff Bodine dedicated himself to rebuilding American bobsledding. With the help of car designer Bob Cuneo, he formed the Bo-Dyn Bobsled Project and began building custom sleds to replace the retread imports the U.S. had been using. “Now the Italians are working with Ferrari; the British have McLaren; the Swiss have gone to Audi,” Cuneo says. “But we were the first team to

acknowledge the crossover between race cars and bobsleds.” Bo-Dyn engineers have spent nearly two decades improving the suspension, streamlining the sled body and studying metallurgy for the steel runners. The payoff: The U.S. team won its first world championship in 50 years last February. Ultimately, Cuneo estimates that about a third of the team’s success in Vancouver comes down to engineering. **PM**

■ **THE COURSE**
The Whistler Sliding Centre on Blackcomb Mountain (below) is the world’s steepest bobsled track. It drops 500 feet over a distance of 4757 feet, a gradient that generates speeds of up to 95 mph.

■ **BODY**
The sled’s 462-pound body is a proprietary blend of fiberglass, Kevlar and carbon fiber. The U.S. team enlisted supercomputing firm Exa to model the sled’s fluid dynamics in order to minimize drag-inducing air vortices that form behind riders’ heads.

■ **CHASSIS AND SUSPENSION**
To minimize energy-bleeding vibrations, Cuneo’s team continuously adjusts the steel chassis and torsion-bar suspension for weather, track conditions, metal fatigue and stress from the g-forces.

■ **RUNNERS**
Because the steel used in running blades is standardized, creativity must come in the design, with variations as tiny as ten-thousandths of an inch. For that, the U.S. team turned to shops that specialize in milling components for jets and subs.

The U.S. team barrels around a bend in a Bo-Dyn ride called Night Train.






Small Boat, Big Fish

If kayak fishing sounds like a surefire way to get a dunking, then check out the super-stable

By T. Edward Nickens
Photographs by Nathaniel Welch

A person wearing a hooded rain jacket and sunglasses is seated in a grey kayak, fishing in a body of water surrounded by tall, dry grass. The kayak is equipped with multiple fishing rods, a blue tackle box, and other gear. The sky is overcast with grey clouds. The water shows ripples and reflections of the surrounding environment.

designs that are opening up a whole new world of angling.

Unconventional kayak designs allow adventurers to pedal to remote locations—and fish two-handed.



The author, fighting a redfish, reaches for his pliers—a feat that is tricky in traditional paddled kayaks.

Sitting sideways in a kayak,

I cast a plug into the inky-black dark of a south Louisiana salt marsh. It's a half-hour to sunrise, but I'm already a mile out after following five other kayak anglers to a tiny island set deep in the wetlands. Now we're catching spotted sea trout as fast as we can cast. All around me I hear lures plopping into the water and my fellow anglers whooping and hooting.

"Whatcha doing over there, Top Dog?" The voice rings out from the far side of the island.

"Filling up the boat, Choupique!"

Suddenly, my rod bends deep. This is no 12-inch trout; I can feel the fish all the way into the cork handle. As I scramble to my feet to put pressure on the line, the kayak holds steady. It's a crazy notion: If I tried to stand in a traditional kayak, I'd be picking marsh muck from my teeth. But my kayak is a new breed, designed from bow to stern to maximize fishability.

For centuries, Inuit paddled one-person sealskin craft in pursuit of halibut, salmon and bottom-dwelling rockfish. Modern sea kayakers have followed those ancestral lines—narrow, cigar-shaped boats that are

fast and efficient yet squirrely for all but experienced paddlers.

Not so with fishing kayaks. Wider and far more stable than traditional sea kayakers, they are easy to paddle solo and can handle breaking waves and open water. And they're tough enough to drag across the driveway and light enough to load on a roof rack. My kayak is a comfortable sit-on-top. Instead of a confining cockpit, it has a self-bailing hull with a padded seat that's as easy to get in and out of as a lounge chair.

These new fishing-friendly designs have ushered in a golden age of small-craft angling. According to the Paddlesports Industry Association, kayak fishing is the fastest growing segment of human-powered water recreation. These boats are introducing outdoor enthusiasts who might never have considered themselves paddlers to a new kind of fishing adventure.

During my three-day deep South blitz, I sample saltwater ponds just a few

feet from highways and back-country marshes so vast that I signal the other anglers in our group by waving my paddle high above the reeds. At one point, my host, Jon Deichert Jr., pulls out an iPhone and uses Google Earth to figure out which labyrinthine marsh creek leads to his favorite honey hole.

Deichert, a southeast Louisiana carpenter and president of the Bayou Coast Kayak Fishing Club (BCKFC), and his pals preach the allure of kayak fishing. "I used to fish from motorboats like everybody else," Deichert says, leaning over the side of his kayak to grab a 16-inch-long redfish. "Once I got into a kayak, that was it. I've paddled right up to river otters, ducks and wading birds. I go places I'd never go in a powerboat. There's less hassle, and I don't have to spend a hundred bucks on gas just to catch a fish."

Deichert's crew has brought along a wide assortment of boats. A few of the sit-on-tops differ little from



1



2



3

KAYAK TECH

1. **Hobie MirageDrive**

Fishing kayaks can be wide and heavy. These efficient, flexible fins propel even the largest kayaks faster than most paddlers.

2. **Rod Holders**

The homebuilt rig shown here enables the kayaker to paddle while trolling with up to four lines. This DIY setup fits in a plug-and-play system integrated into the kayak's design.

3. **Marsh Anchor**

Mucky bottoms require a special anchor. This one, rigged from a flounder gig, keeps a boat steady in the softest mud.

tournament director. "Maybe personal fishing craft comes closer to the idea."

But not every kayak angler goes for the slick new bells and whistles from the R&D departments of boat manufacturers. Joe Barbier, who trades rigging tips like family recipes, prefers make-it-work accessories. The gregarious truck driver proudly shows off his homemade upgrades: a depthfinder mount that holds a transducer in the water; a retractable flashlight system he uses to raise a beam above the boat while paddling in the dark; and an anchor made from a flounder-gig lure that rides vertically inside a PVC tube. A tee fitting allows him to operate a release line from the paddling seat, driving the gig into the Louisiana muck to hold the boat in perfect casting position. "I could buy this stuff," Barbier says, "but I got a liking for making things I can put on a kayak. Give me PVC, aluminum stock and pop rivets, and I can perform rigging miracles."

On my last day in the marsh, I try out the catamaran-like Native Ultimate hybrid, which seems as stable as a

floating dock. I alternate paddle strokes with casts, the kayak parting curtains of green and gold reeds, its passage silent save for the sibilant hiss of marsh grass on polyethylene.

Suddenly a 30-inch redfish jets from an underhang of marsh muck, slashing at the lure not 5 feet from the boat. "Whoa!" I holler, the strike so sudden and close that it's almost entirely unexpected even though I

am, in fact, fishing. I set the hook and hang on as the fish tugs the kayak in a full 360. Three times I reel in the redfish, and three times it screams away. When the fish finally succumbs, finning gently beside the boat, sunlight flashes on its copper flanks.

It's when I pull out the pliers to free the fish that I realize there's not another soul in sight, no one I can brag to about the catch. Thanks to the kayaks, each of us is off in our own world of water and grass. And I wouldn't have it any other way. **PM**

THE NEW NANTUCKET SLEIGH RIDE

The most extreme kayak angler may be Chicago futures and options trader Dave Lamoureux, who paddles a modified 12-foot-long recreational kayak off the tip of Cape Cod in pursuit of bluefin tuna. He's had strikes powerful enough to tow him at 15 mph—a contemporary variation of a whale

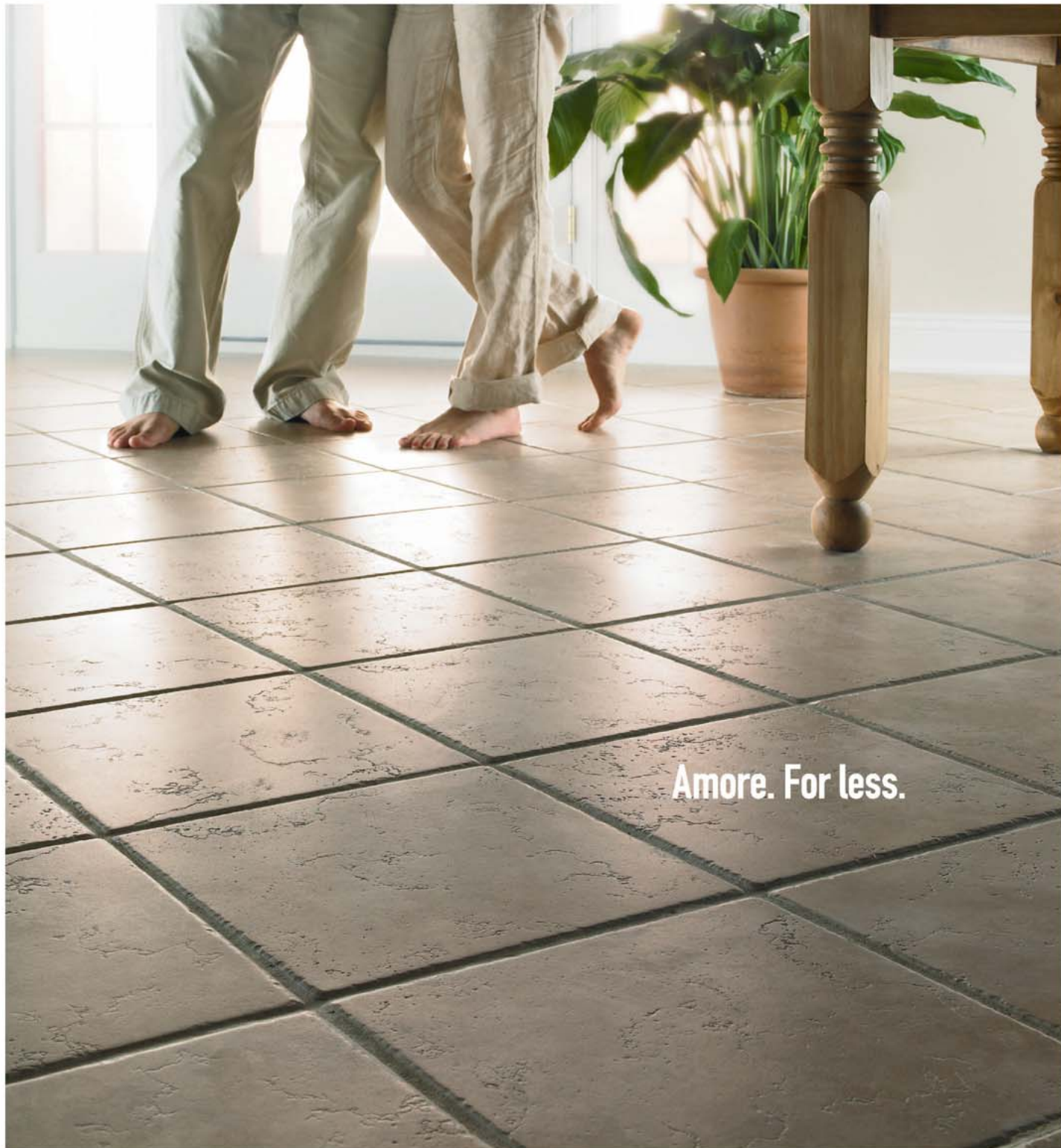
pulling a whaling boat in what Herman Melville described as a Nantucket sleigh ride. In November Lamoureux reeled in his biggest catch to date—a 157-pound bluefin (at right). "Tuna are so big and fast," he says, "the initial hit is extremely violent. I've had my kayak cracked."



nonfishing models except for rod holders. Some of the hybrid craft look like a cross between a canoe and a kayak, with built-in mounts for fishing electronics and pontoon-boat hulls that provide extra stability for standing anglers. Other outfits sell kayaks with a split hull and rear sections that pivot to form outriggers. And some kayaks have profiles so wide you can stand while paddling.

The Hobie I take to the trout marsh is similarly unbound by traditional

designs. It's outfitted with the MirageDrive propulsion system, a pedal-powered pair of flexible fins that function as oscillating foils—much like penguin and sea-turtle flippers. Not only does the kayak move more quickly than a paddled model, but I can two-hand a fishing rod while cruising across the water. And it's equipped with a system that allows me to drop the anchor off the stern with just a tug on a cord. "These things stretch the term kayak," says Brendan Bayard, BCKFC's



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diy

Home

Turf War

WE PIT EIGHT MOWERS AGAINST REAL-WORLD LAWNS—AND EACH OTHER. BY ROY BERENDSOHN

➔ **Years of testing** have taught us that any lawn machine can cut grass under ideal conditions. The question is how well it does amid the vagaries of the real world—where the grass is often dry and brittle or wet and tall, there are steep hills to climb and you have to coax the mower over roots.

Those conditions are what we faced when we tested the new crop of convertible mulching mowers—

machines that cut and broadcast clippings, and bag them or mulch them back into the grass. We gathered eight mowers at a farm at the edge of the Catskills in lower New York state. All but one had a 190-cc engine; we threw in a high-torque 160-cc model to keep things interesting. Then we put the mowers to work on and off over three weeks of sun, wind and rain. Here's our report.

INSIDE × COVE-BASE CORNERS + DOUBLE-DUTY TOOLS + DEAD SHORTS

**** CRAFTSMAN 37436

PRICE: \$430 TORQUE: 7 LB-FT DRIVE: REAR-WHEEL

DRIVE CONTROL: FIXED-HANDLE; RIGHT-HAND

SPEED-CONTROL LEVER NOISE: 93 dBA

LIKES "A sweet ride." That's how one of our testers described the quick-clipping Craftsman. One example of its smart design is the spring-loaded height adjustment. Pull up on the large red grip at each wheel and pivot to the correct height setting. Let go of the handle, and the height-adjustment pin snaps sharply into its hole. Other nice details include the well-shielded drive belt under the deck and a responsive squeeze-handle drive lever.

DISLIKES Louder than other mowers. Grass built up under the deck, at the rear mulch plug, though it didn't interfere with mowing. (We also tested the \$500 Craftsman 37103. We found it pleasant and clean-cutting, but too slow for our tastes.)

**** JOHN DEERE JS36

PRICE: \$400 TORQUE: 7 LB-FT DRIVE: REAR-WHEEL

DRIVE CONTROL: PIVOTING TOP-HANDLE NOISE: 91 dBA

LIKES Easygoing operation. The John Deere's drive speed is quick to adjust using a pivoting top handle (Deere calls it the MowMentum system), and there's so little rolling resistance that with the engine off, the machine just skates down the driveway or around the garage. One pull starts the mower, and one easy-pivoting lever raises and lowers the deck.

DISLIKES The pivoting top-handle drive control seems better suited for simple cut patterns, not the elaborate back-and-forth action or pivoting moves that some yards require.

***** HONDA HRX2172VKA

PRICE: \$700 TORQUE: 8.3 LB-FT DRIVE: REAR-WHEEL

DRIVE CONTROL: FIXED-HANDLE; DUAL-THUMB

SPEED-CONTROL LEVER NOISE: 89 dBA

LIKES The luxury car of walk-behind lawnmowers. The Honda leaves a velvet finish, thanks to a unique dual blade and a domed plastic deck that keeps the clippings suspended as they are cut and recut. The mower stays unusually clean as it cuts, both in wet and dry grass, or even as it plows through a pile of dry leaves. Niceties include a large fuel cap that's easy to turn and tool-free air-filter access.

DISLIKES Someday, Honda will redesign the deck-lift levers, which are small and uncomfortable to use. In the meantime, they mar an otherwise outstanding machine.

**** HUSQVARNA 7021R

PRICE: \$350 TORQUE: 6.9 LB-FT (160-CC)

DRIVE: REAR-WHEEL DRIVE CONTROL: FIXED-HANDLE;

RIGHT-HAND SPEED-CONTROL LEVER NOISE: 90 dBA

LIKES Power, pure power. Equipped with an overhead-cam Honda engine, this mower feels like it could slice its way through a wheat field. It's one of the last machines with a choke lever, handy for cold-climate users who prefer a slightly fuel-rich start. Shift to choke and pull on the recoil start handle, and it starts instantly; the choke lever travels automatically to the run position. The mower also offers responsive speed control, single-lever deck adjustment and excellent below-deck shielding of the drive belt.

DISLIKES The control bar is uncomfortable.



BEST
OVERALL



***	POULAN PRO	PR625YRKP
PRICE:	\$300	TORQUE: 6.25 LB-FT DRIVE: FRONT-WHEEL
DRIVE CONTROL:	FIXED-HANDLEBAR; SPEED-CONTROL BAR	
NOISE:	92 dBA	

LIKES Easy starts. The key-ignition option worked well, and the mower started almost as easily with a pull.

DISLIKES We reviewed two of these mowers and found the rear-wheel brackets on both to be flimsy. In fact, one of these brackets broke right out of the box. We welded it. We also found that the drive belt under the deck was poorly protected—an hour's worth of cutting left the belt area plugged. In the past, Poulan Pro products have tested out as rugged and reliable, but not this mower.



****	SNAPPER	SPVH21675
PRICE:	\$449	TORQUE: 6.75 LB-FT DRIVE: REAR-WHEEL
DRIVE CONTROL:	PIVOTING TOP-HANDLE NOISE: 91 dBA	

LIKES This is a great idea. The Snapper is equipped with a device called a Fresh Start insert in its gas cap. This slowly releases a drip of concentrated fuel preservative into the gas tank. When the insert runs dry, the user snaps a new one into the cap. By preserving the gas in the mower instead of your gas can, you're always assured of stabilized fuel during the cutting season, regardless of how many cans of fuel you run through. Additionally, with a rated top speed of 4 mph, the Snapper is a quick clipper.

DISLIKES Like the Deere, the Snapper's top-handle drive control is better for cutting open areas, not for intricate, back-and-forth mowing.



****	TORO	20332
PRICE:	\$389	TORQUE: 6.75 LB-FT DRIVE: REAR-WHEEL
DRIVE CONTROL:	SLIDING TOP-HANDLE NOISE: 91 dBA	

LIKES Top-to-bottom attention to detail. Toro's engineers designed a mower that suits a variety of users and mowing conditions. Leave the bag on the mower and switch between mulching and bagging with the flip of a lever near the rear wheel. Mow at your own pace by simply pushing more firmly against the handle, which slides forward and makes the mower go faster. Back off the pressure to slow down. Other features combine to make this a value-packed product: a fitting where you can attach a garden hose for washing the underside of the deck, and a three-year warranty that covers the mower's drive system and ease-of-start capability.

DISLIKES Nothing noted.



****	TROY-BILT	TB230
PRICE:	\$290	TORQUE: 6.75 LB-FT DRIVE: FRONT-WHEEL
DRIVE CONTROL:	FIXED-HANDLEBAR; RIGHT-HAND SPEED-CONTROL LEVER NOISE: 90 dBA	

LIKES Value. That pretty much sums up this mower. It gives you deck-height control with two levers (instead of the usual four), a deck washout fitting, a simple and responsive drive control and the ability to handle bumps and bulging roots, thanks to an 11-inch-diameter rear wheel. Those tall wheels paired with front-wheel drive make it a hard-working and maneuverable mower that also happens to be easy on your wallet.

DISLIKES The front deck comb is too sharp. You need work gloves to lift the mower into a trunk.

BEST
VALUE

Homeowners Clinic

by Roy Berendsohn

Q+A



Three-Step Corner Cut

Step 1
Hold the cove base in position and mark the corner with a sharp pencil or a fine indelible marker.

Step 2
Fold the cove base firmly over so that the inside is face up and the line is in the center of the fold.

Step 3
Pare along the marked line using a sharp utility knife. Flare the cut slightly toward the bottom.

Cutting Corners

Q I installed vinyl cove base molding in my kitchen and front foyer because we mop those floors regularly, and all that cleaning ruined the wood baseboard trim that was in there. The problem is that I can't make the outside corners of the cove base look nice. I tried folding the cove base around the corner, but it won't stay put. The pieces that I put down are already pulling loose. I tried cutting an outside miter on it but found that I couldn't cut it accurately. How do pros get those nice, crisp outside corners?

A The secret to a good outside corner on cove base is on the inside, which is grooved with a utility knife. (You can also use a specialty flooring tool known as a top-set cove-base gouge, but unless you handle hundreds of yards of cove-base material, it probably doesn't make sense to buy one.)

The installation of an outside corner works like this: First, hold the cove base against the corner, and mark the corner location on the molding with a sharp pencil or an indelible marker. Now fold the outside face of the cove base against itself so that the marked line is at the center of the fold. Use the utility knife and pare across the width of the vinyl along the folded edge. This leaves a groove on the molding's back that matches the rounded edge of the dry-wall corner. It also creates a thin area that allows the molding to stretch as it's wrapped around the corner.

You'll produce a neater fit if you flare out the groove ever so slightly at the base of the molding (a tip we first ran in PM in the 1940s, by the way, in an article that describes installing linoleum base molding). By widening the groove, you let the molding stretch more where its vertical face meets the rounded cove at the base. Finally, if the cove does not meet the floor neatly, pare away the tiny ridge at the bottom of the molding. Spread vinyl-cove-base adhesive on the cove-base back and press the molding into place. Professional flooring installers work over the molding with a rubber roller to ensure it's bonded firmly.

The Leak Technique

When it rains all day, water leaks into our basement. We removed some drywall and found a crack in the foundation that looks like somebody had tried to repair it by smearing some concrete over it. How do we really fix the problem?

It seems logical to use concrete to seal a crack, but a better material is water-stopping mortar. It expands as it cures.

First, remove enough drywall to get at the full length of the crack, then remove as much of the patch as you can using a hammer and a masonry chisel. Next, push the water-stopping mortar into the crack using a trowel.

That takes care of the inside. I'd dig

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down and do the same thing on the outside. It's also likely that you've got a plugged foundation drain or a downspout discharges right next to the house. Take care of these and let the repair go through at least one rainy stretch of weather before repairing dry-wall damage on the inside.

Duct Seal, the Real Deal?

I have a two-floor raised ranch that's 25 years old, and from what I can see, the ducts aren't very well sealed.

There are companies such as AeroSeal that claim they can seal air leaks from inside the ducts. Is this service legitimate, and is it worth the money? Can I seal the ducts myself?

I haven't used it at my house, but AeroSeal looks to be a legitimate process that's well-engineered. And it should be. The technology was first developed by Lawrence Berkeley National Laboratory. The contractors

who license it are trained and specifically equipped. In other words, you can't buy the components at a hardware store and simply set up shop. Given that it's not unusual for a house to lose 10 to 20 percent of heated and cooled air through leaks, it's likely the process can pay for itself. The more severe the leakage, and the greater the demand on the house's heating and cooling system, the quicker the payback.

Here's how the process works. First, the duct outlets are sealed and the duct is pressurized. A pressure reading is taken that measures the amount of air escaping. Next, a fog of dry adhesive particles is blown into the duct. The particles stick in places where the air stream makes a sharp turn to exit through a leak. The adhesive builds up at this point, eventually bridges the gap, and seals the leak from the inside.

The cost for an AeroSeal application can range from \$1500 to \$3000. One of the best aspects of the technology is



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the documentation that shows the reduction in the duct's leakage. Not only does this provide some peace of mind to the homeowner, it's also proof for potential buyers.

Can a homeowner seal the home's ducts? Yes. (For a handy tutorial, visit rcdmastics.com.) It's hard and dirty work, and there's more to it than making a wrap around a leaky joint using duct tape that will later fall off.

First, you have to make a thorough inspection of air-conditioning and heating vents and the places where the duct passes through. That usually means crawling around in an attic or crawl-space, and it can mean standing in weird positions on a stepladder while using a telescoping inspection mirror to look at joints and seams that are not easily visible. Then you have to seal with mastic and perhaps fiberglass mesh, if the gaps are quite large.

It can take a fair amount of grit and determination to get at these spots, and unless you hire a heating-cooling contractor to test-pressurize the system, you have no proof of how effective your efforts have been. Still, the more thorough you are, the greater your likelihood of success.

We Have Lutoff

When removing old wall-to-wall carpet in a bedroom, I discovered and removed the 9 x 9 resilient floor tiles below. Although the tiles came up easily, there is a layer of black mastic left on the subfloor. It's not sticky. Should I scrape this stuff up before putting down new carpet?

I wouldn't. It's possible that the old adhesive has asbestos fibers in it. It's best left undisturbed. Rather, I'd floor over the material with $\frac{3}{16}$ -inch lauan plywood. That will give you a nice clean surface to install new carpet on.

If for some reason that won't work (for instance, the increased floor height caused by the plywood makes for difficult floor transitions), you could scrape off the mastic after softening it with mastic remover. (First send a test sample of the mastic to a lab to determine if it contains asbestos.) Do not use a petroleum-solvent mastic remover for this work. Instead, try a soy-based or similar product. These work more

slowly than their petroleum-based counterparts, but the fume reduction makes it worthwhile.

Bad Trip

I've got a circuit breaker that's permanently tripped. It's in a part of the house where we don't spend much time, but I noticed there was no power in the wall outlets. So I went to the service panel and found the tripped breaker. It tripped with a small pop when I reset it. What causes this?

Based on your description, it's almost

certainly a wiring problem that electricians describe as a "dead short." Somewhere in the wiring the so-called hot wire (more officially known as the ungrounded conductor) and the neutral wire (known as the grounded conductor) are making contact. Usually, these two conductors are only connected via an electrical load such as a light or an appliance. When there's no load between them, you get a massive inrush of current that trips the breaker. A similar thing happens if the hot wire makes contact with the grounding wire (known as

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the equipment-grounding conductor). Fortunately, the breaker is doing its job and is opening the circuit.

Is it possible that it's just an old circuit breaker with a worn-out spring? Usually a breaker like that trips without the popping noise. Also, it's not usually instantaneous. That is, you can reset the breaker and it will hold for a little while, but eventually it will trip on its own. I wouldn't simply replace the breaker, though. That's gambling, not diagnosis. Determining whether the breaker is bad requires knowing how to work safely inside the service panel and how to use a voltage-ohm multimeter.

I'd recommend you call an electrician. The problem can be simple, such as two old wires with frayed insulation that have come into contact in a receptacle box, or it can be complex, such as water leakage in the service panel that has resulted in some rotted wiring.

Worth the Weight?

A vinyl-fence website says its stuff is better than the vinyl fence you can buy at a home center. Is this true?

Sometimes the only vinyl fence available at a home center is lightweight and pretty thin. The posts, for example, are really a sleeve. You put a pressure-treated post in the ground and slip the vinyl sleeve over it.

The heavier vinyl fence that contractors use is available through websites, some lumberyards, vinyl supply houses and landscape supply centers. With these systems, the posts generally don't need reinforcement, except at gates. In that case, the supplier usually makes an aluminum insert specifically designed for gateposts. With some of these fence systems, other parts such as the lower support rail are also reinforced with heavy-gauge aluminum.

Does this mean that these systems are better? That's a tough call. Although they're not difficult to install, they are not as easily installed as the systems you'll find in home centers, which are designed with homeowners in mind. To my casual observation, these fences are less likely to sag over time, and they

seem more wind-resistant. Given enough abuse (such as a flying golf ball or ice chunks hurled by a passing snow plow), any vinyl fence can be damaged.

Finally, regardless of the system you use, contact your state's One Call system to locate underground utilities before beginning fencework.

Feeling Flushed

We have toilets in back-to-back bathrooms that are showing poor flush performance. We had the drain cleaned, and both flush valves are only a couple of years old. The toilets are about 10 years old, and they just seem to be performing more poorly. The house is about 50 years old, if that makes a difference.

It's a classic problem. Here's an easy check. Stand in one bathroom and simply observe the water in one toilet (without flushing) while someone in the other bathroom flushes that toilet.

It's likely that you'll see the water in the unflushed bowl bob up and down. That indicates a lack of air available through the roof vent. A similar thing happens in properly functioning plumbing when a strong wind blows over a roof vent, pulling a vacuum on the water in the toilet's trap. Okay, I admit that it seems weird to stand there and watch for this on a windy day. If your wife gives you a hard time, you can blame it on us.

Plumbing-vent problems are not unusual in older homes. As the home ages, branches grow out and overhang the roof. All it takes are a couple of leaves or seedpods a year to fall into the roof vent opening. Eventually, this spells trouble for the vent system. Clean out the roof vent with a long piece of hooked wire. The problem should go away. **PM**

Got a home-maintenance or repair problem? Ask Roy about it.

Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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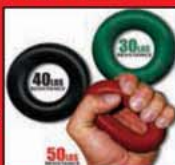
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Cold Storage

JUST BECAUSE YOUR CLASSIC MAY BE OFF THE ROAD DOESN'T MEAN YOU CAN SKIMP ON SERVICE. HERE'S HOW TO GET YOUR CAR READY FOR STORAGE. *BY MIKE ALLEN*

→ **"Greetings from** the President of the United States." That's what it said when my draft notice came in the mail, a couple of wars ago. But instead of thinking about how hard it would be to leave my family and friends for months, or years, I had another thought that ping-ponged around inside my head. What to do with my

beloved and pampered 1965 Mustang? It was just too dear to my heart to part with, and I didn't dare leave it for my parents to drive—or worse yet, my little brother. It would just have to be pickled, and put up on blocks for the duration. That was a long time ago, and I wish I had done a better job of preserving that car, so I could drive it today. Yes, I miss that Mustang.

There are lots of men and women serving in our armed forces around

This Porsche is getting the royal treatment for its wintertime nap: a cool, dry indoor storage facility, a fitted cloth car cover and freedom from vermin. It'll be like new in the spring.

INSIDE



STORAGE + BELT TIMING + OILY MAYONNAISE

the globe. And I receive plenty of mail from them asking me how they should store their cars while they are overseas. The rules of vehicular cold storage are the same no matter why the car is left behind. But storage isn't always kind to vehicles. Corrosion and decay take their toll on engines, bodies and interiors. Time itself can ruin tires, and even a car stored inside a garage can attract some unwanted furry house guests. Here's how to protect and store your car, truck or motorcycle—the right way.

Store or Sell?

→ **Unless there's something** very special about a particular car, I don't suggest placing a car in storage for more than a year. Special-interest and collector cars, like that 1966 Vette or antique Hispano-Suiza, might tug on your heartstrings (and purse strings) enough to keep them in the family, but anything that qualifies as practical daily transportation, no matter how nice it is, should be sold. You can replace it with another car when you're in need of a vehicle again. The loss in value of a car that accrues in another year from its manufacture, even if the odometer doesn't see any more miles, is too high.

One option for shorter-term situations is to simply keep the car on the road. Find some responsible adult who will drive the car every two or three weeks for an hour or more. This will keep the drivetrain lubricated and the battery charged. An engine that doesn't

run regularly collects moisture and internal rust, especially on the portions of the cylinder walls not covered by the pistons, valves, camshafts and valve springs. Ditto for the brake discs, which are made from easy-to-rust cast iron. A car that's driven far enough to get completely warm and remain that way for an hour or more will drive off the moisture, coat any lubricated surfaces with oil again, and sweep the rust off the discs before they start to pit.

And keep your insurance active: In some states, dropping your car insurance, even if you're not going to be driving, will make it nearly impossible or very expensive to get insurance again when you're ready. Check with your insurance agent; he may be able to reduce your coverage or transfer it to some less expensive option. At the very least, you'll want theft and vandalism coverage—just in case.

Where to Park It

→ **If you must** tuck your car away for an extended period of time, the best thing you can do is find an appropriate place. Obviously, storing the car indoors is best. But if outside is the only choice, find a spot that's dry, away from the sun's rays and far from trees. Trees have leaves or needles, which will land on your car and can trap moisture. Trees also have birds with poor toilet habits. If possible, pick a spot that isn't infested with vermin, so avoid leaving the car near a woodpile or a row of garbage cans. Some car manufacturers use wiring insulated with plastic derived from soybeans, and rodents will eat it clean off the wires. They'll chomp on rubber hoses and belts. I once had a mouse nest that blew out of my exhaust system when I fired the car up—and it nearly set my garage on fire.

At any rate, there is plenty you should do. Start with a thorough cleaning, inside and out. If you live where they dump salt on the road in winter, break out the pressure washer and get all that

1. Moth Crystals

Keep furry vermin from eating your soy-based wiring insulation or using your seat foam for nesting material. I won't even mention the urine. Put a dish of moth crystals covered in aluminum foil inside. Renew several times a year.

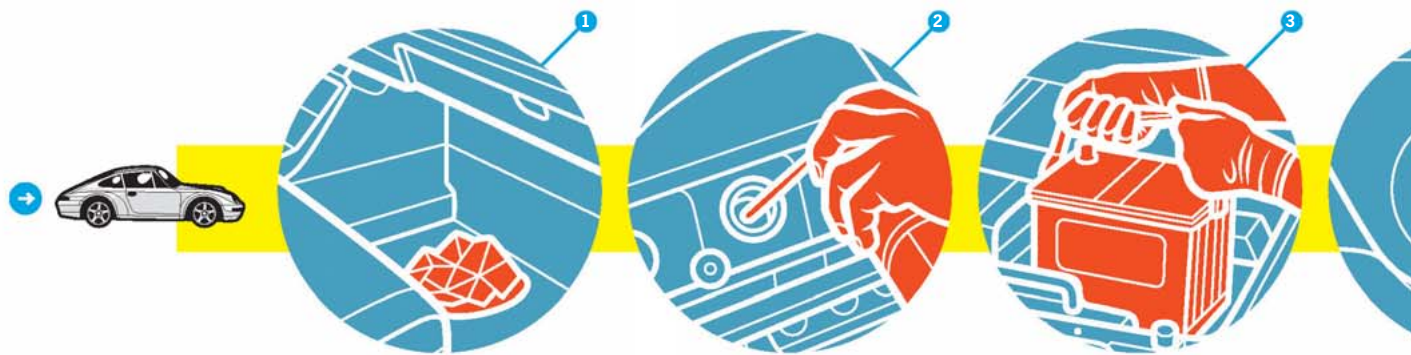
2. Fogging Oil

We bought this at a marina, but you could order it from the auto parts store. This preservative oil creeps into the internal parts of the engine and prevents rusting on machined surfaces. Spray liberally into all the spark plug holes.

3. Battery Removal

Remove the battery from the car. For short-term storage, you can leave it in place disconnected, but it's better to remove the battery and store it someplace where it's above freezing and dry. Clean the surface of

conductive oil, dirt and corrosion, and keep it charged with a proper battery maintainer, not just a trickle charger. For long-term storage, give this one to someone who needs a battery and buy a new one when it's time.



salt off the undercarriage.

If your coolant is more than halfway to its expiration (either two years for conventional coolant or five years for long-life coolant), flush and refill with fresh, which will have more anticorrosive additives available for the long haul. If there are any leaks in the cooling system, engine transmission or axle, better to fix them now rather than after they've bled fluids all over your floor—and before they leak dry and leave your gears or other metal parts exposed to corrosion.

Use a marine-style fogging oil to protect internal engine parts. On carbureted cars, spray directly into the carburetor while the engine is at idle, until the engine dies as the plugs are oiled down, then pull the plugs and spray a 10-second blast into each plug hole. Replace the plugs. If you have fuel injection, especially if your injection system uses an MAF sensor, skip spraying into the intake lest you damage the sensors—just do the plug holes.

For short-term storage, you can simply remove the battery's negative cable,

and connect a battery maintainer. For longer-term storage, remove the battery and store it indoors in a dry place above freezing, again, with a battery maintainer.

If you're storing inside, under a cover, leave the windows cracked open an inch to prevent moisture and funky smells from collecting. If the storage area is genuinely secure, prop the doors and trunk open a few inches to keep from compressing the gaskets. Worried about spiders? They'll get in even if the doors are closed and the windows are up, so relax. Speaking of the gaskets, give all the rubber door, window and trunk gaskets a generous coating of silicone spray or, better yet, silicone grease to keep the rubber from getting hard.

Once you have the vehicle prepped inside and out, jack the car up and support it on four proper jackstands—but only if the floor is concrete. Soil, gravel and even asphalt are too unstable for the long haul. Now you can remove the wheels for storage, which will keep the tires from flat-spotting and the wheels

from corroding. It'll also give you access to the brakes. You did remember to loosen the lug nuts before you jacked it up, right? Keep the wheels and tires somewhere dry and cool, and nowhere near ozone-generating electrical motors. Let the air out of the tires. If you must store them outdoors, at least cover them to keep the UV in sunlight from degrading the rubber. If you are storing a car for five years or longer, you should probably sell those tires now and purchase new ones when you are ready to get back on the road.

Take the last of the fogging oil that you used inside the engine and spray the brake discs with a thin coat to keep them from rusting. Avoid getting oil on the calipers, because the rubber caliper boots and seals won't like the hydrocarbons in the oil.

Starting Over

→ **You're back in town**, ready to start driving, so it's time to unpickle your ride. Start by reinflating your tires with some nice, dry air. How do you know if the air is dry? Depress the inflator-nozzle pin with your finger. If your finger gets wet, you've got water in the hose, caused by atmospheric humidity collecting in the compressor tank. Moisture inside the tires will corrode the rims and degrade the rubber. Fill with either dry air or nitrogen.

Clean the brake discs by showering them with aerosol brake cleaner, and reinstall the wheels. Use the floor jack to lift the vehicle off the stands and remove the car cover. If you've left wax on the surface, polish it off. Change any fluids that weren't changed immediately prior to storage, especially the brake fluid.

Install the battery, which should have plenty of charge if you've kept it on a maintainer. If you've fogged the inside of the engine, it'll probably be a little hard to start, so be prepared to swap out for new spark plugs if a minute or two of cranking won't light the fires. Avoid using ether-based starting fluid. I saw a guy punch

a connecting rod right through the side of the engine block on his S-10 by using ether. A little judicious priming with aerosol carb cleaner might help, but don't lose your eyebrows.

PM

4. Fuel Stabilizer

Add the correct amount of fuel stabilizer to the tank to keep the fuel from oxidizing and turning into varnish. Fill the tank to the brim to prevent condensation in the space above the gas, then run the engine long

enough to circulate the stabilizer.

5. Cleaning

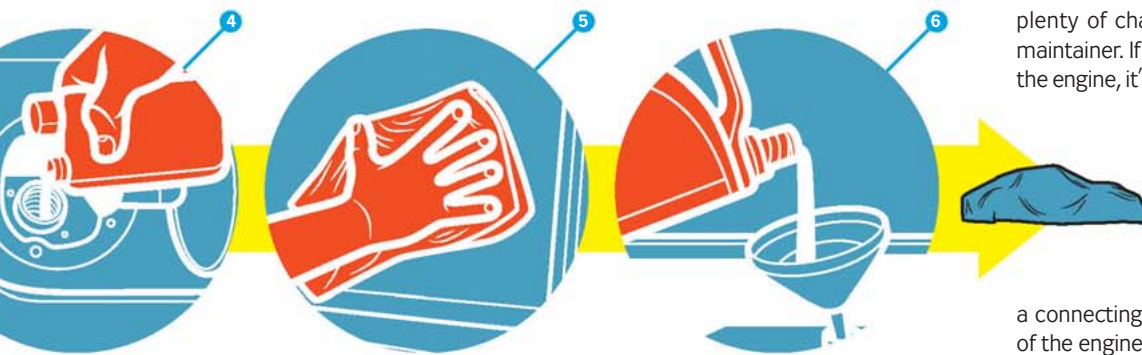
Clean the interior and shampoo the upholstery and carpets so stains don't get a chance to set. And remove all those French fries and Jujubes that attract insects and rodents. Send me all the loose change you find.

Then wax the outside, but don't polish all the wax off, so the surface has an extra layer of protection. What kind of wax? It doesn't really matter, as long as it's car wax. Then use a cloth car cover, not a plastic tarp, which will trap moisture and scratch the paint. If

you're storing indoors, you might get away with using a clean bedsheet or new fabric dropcloth.

6. Oil Change

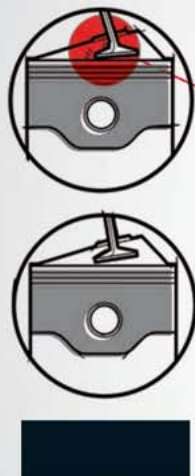
Change the oil and filter, although I'd recommend changing them again within a few miles after coming out of storage.



Car Clinic

by Mike Allen

Q+A



Improper camshaft timing can destroy an engine instantly, as the piston smashes into the valve head, bending the stem. Not all engines will suffer this fate, however.

Bad News Bearer

Q I replaced the water pump in my 2003 Mitsubishi Outlander. When I tried to start it, the cam timing was off. So I adjusted that, and now it will crank but won't start. At one point I had white smoke and the smell of fuel in my air-filter box, but no actual fuel there. Please help.

A Ah, the epic, classic fail. The good news is that now you probably have your timing belt timed correctly. The bad news is that you've severely damaged your engine. Who would think something as simple and low-tech as replacing a water pump could totally trash an engine? From the top: You removed the timing belt to get to the water pump, which happens to be mounted behind the timing belt. It's very clear to me, ex post facto, that you reinstalled the belt out of time, which is easy to do. That's especially true if you didn't realize that it needed to be installed with the pulleys aligned prop-

erly. (It's too late now, but I also hope you used a new belt.) Specifically, the crankshaft and the camshaft had to be properly indexed before you slipped the belt into place, preserving the phase relationship between the crank and the cam. The crankshaft rotates twice for every turn of the camshaft—but I'm not going to take up half the column to explain basic four-stroke engine theory, at least not this month. When you tried to start the engine with the cam improperly timed, some of the valves were still at least partly open when their respective pistons came to top dead center. Two physical objects can't

occupy the same place at the same time (see Einstein's theory of relativity), and the aforementioned valves bent.

This was bad. Bent valves don't seal against the valve seat very well. But once you realized your mistake, you did fix the incorrect camshaft timing. The bad news: Now your engine has no compression, because the valves aren't closing, allowing the air/fuel mixture to be pumped back upstream into the air cleaner. Unfortu-

nately, you must now remove the cylinder head to replace the bent valves, and maybe the pistons, connecting rods and crankshaft as well. Next time, read the manual first.

Not all engines will be damaged by an out-of-time or even a failed timing belt. If the valve doesn't open far enough to hit the piston, it won't bend. Why don't they just make these engines so the valves won't ever hit the pistons, even if the belt snaps or goes out of time? Some engines, referred to in the industry as noninterference engines, will indeed suffer no damage when the belt goes south. Yours, however, is not

one of these. Noninterference engines tend to be low-performance dogs because the valves have to open far enough to gulp air/fuel mixture to make power. Shallow valve lift equals less power.

Civic Longevity

I own a 2007 Honda Civic EX sedan with an automatic transmission. I want to get the most from this Civic, so I take care of it, drive it gently and plan to use it until it just won't run anymore. When I commute to work, I have a choice of driving about 30 miles one way over a steep and twisty mountain road, or driving 40 miles on a more level surface and at a steady highway speed. Which route would you recommend for the longevity of my car?

This one is a tough call. Exactly how twisty is the mountain road? Faster steady-state driving is better than canyon carving. But in your case you're driving 33 percent farther to achieve this wear-and-tear savings. If you can drive sensibly, without using a lot of throttle, downshifting and heavy braking, the mountain route might actually be no harder on your car. Spirited driving will consume more tires and brakes—but I can outdrive most people on a mountain road I know well without using much of either. As they say, your mileage may vary.

Without knowing anything about the road, I'll suggest you take the route that consumes the least amount of fuel, in total—not per mile. That's probably the best indication of how hard you're using your car.

Mysterious Drifter

I have a 2008 Mercury Mariner Hybrid with 8000 miles on it. I have noticed that the Mercury wants to veer left, ever so slightly. I have visited two dealers, and both have said there is nothing wrong, but I know differently. I find that it requires slightly less effort to turn left than it does to turn right. On older cars with power steering, you had a way of adjusting the power unit. But they tell me these

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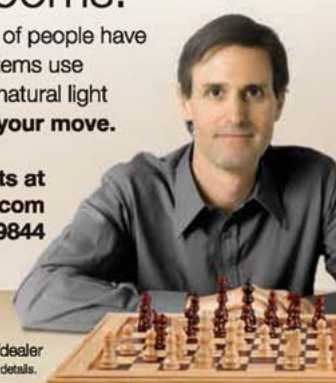
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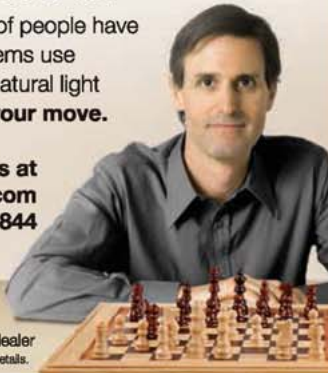
 

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Q. What is the difference between a water sealer and a waterproofer?

A. Water sealers generally only repel water, while a waterproofer must be tested to withstand hydrostatic pressure. Hydrostatic pressure is the pressure exerted by a column of water behind the wall surface. It is measured by PSI (Pounds Per Square Inch). An average basement is 9 feet in height; if water is the full height of that basement it would be equal to 4 PSI. DRYLOK was Independently Tested to meet 10 PSI!

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newer ones do not and that there is no adjustment. What's the truth?

There is no left-right adjustment on your steering rack. Some old-fashioned recirculating-ball steering boxes had an adjustment, but that was used only for taking up slack as they wore, not to correct a tendency to veer left or right.

However, there are plenty of adjustments in the Mariner's suspension for camber, caster and toe-in—at both the front and rear. I don't suppose anyone has actually checked the alignment beyond just taking a test drive around the lot? Another cause might be a bad tire or one that's worn in an odd way. If the alignment is okay, try a tire rotation to see if the problem changes sides (but it probably won't go away). You may need to replace one or more tires.

More data: Because road surfaces are crowned off to the curbside, many manufacturers bias a vehicle's suspension settings to compensate. Specifi-

cally, they call for different camber settings between the left and right front wheels, which can make the vehicle tend to veer left on absolutely flat roads. The factory alignment specifications for your Mariner are symmetrical, however.

Synthetic Recycling

I have a question about recycling synthetic motor oils. Can it be done? I have never heard anything about the proper disposal of used synthetic oil.

Synthetic or synthetic-blend motor oils should be disposed of just like conventional mineral oils. In most states, any place that changes oil commercially is required to accept small quantities of used motor oil from consumers for free. These establishments send this oil to recyclers, where it's used as the base stock for other petroleum products, including motor oil. There are also some places that burn it in special furnaces for space heat in their shop.

NOW YOU KNOW

Proper Diagnosis Pays Off



Wintertime is generally no fun, at least in my opinion. One cold day, a neighbor brought me his car, distraught. His mechanic had told him he had a head or manifold gasket leak, and that his oil was heavily contaminated with coolant. Uh-oh. A manifold gasket leak could cost several hundred bucks to remedy. A head gasket leak requires maybe a cool grand to fix. **Bad:**

I pulled the dipstick, and it was covered with dark brown glop that had the exact consistency of mayonnaise. Ditto for the

underside of the oil-filler cap. Good: There was no evidence of *any* oil in the coolant. So I started asking questions. What is this vehicle's

usual drive cycle? He mentioned the car was used only for short errands around town. But the real clue was the weather. We had experienced weeks of snow and temps in the teens. Diagnosis? Not a bad gasket, but an engine that had a lot of moisture built up in the crankcase.

On those quick trips, the oil temperature never got high enough to drive the water out of the oil and into the PCV system. Just to be sure, we changed the oil and filter, which appeared normal. The dipstick tube and oil cap were simply in an area of the engine compartment that never got warm, and the moisture emulsified with the water, making glop remarkably like mayonnaise. Cure? An occasional trip of an hour or so on a warmer day to allow the water to be driven off.

If neither scenario is an option, contact your local Department of Public Works, or even the local fire department, to see what the proper disposal methods are.

Charged Up

I made a human-powered battery charger consisting of a bicycle and a Bosch 65-amp alternator (salvaged from an old BMW) for my emergency power system, which consists of a bank of RV batteries maintained by a 20-watt solar panel. I can produce about 15 amps comfortably with the bicycle when I use light bulbs as the load. But when I try charging the batteries, they only accept around 3 amps unless they are deeply discharged. So I spend a lot of time pedaling to keep the batteries charged when I need backup power. Am I correct that raising the output voltage of the alternator will increase the rate the batteries charge? How do I accomplish this? All Bosch regulators that I have seen appear to have the same (or very similar) voltage output.

First of all, a lead-acid battery's charging-current profile tapers off substantially as it reaches about 50 percent of its capacity, even if the charging voltage is correct. Raising it above 14.5 to 14.7 volts won't make it charge any faster and will damage the battery. An automotive alternator is a constant-voltage device, and it's not optimized for rapidly charging a battery. The charge time of a sealed lead-acid battery is 12 to 16 hours (up to 36 hours for larger capacity batteries). With higher charge currents and multistage charge methods, the charge time can be reduced to 10 hours or less. Lead-acid cannot be fully charged as quickly as nickel or lithium-based systems. After approximately half of the battery's capacity is reached during the bulk phase of charging, the current will taper off while voltage rises slightly.

What's the battery voltage when the current starts to taper off? I'd say, charge for a while, then let the pack rest for an hour with no charge or discharge and measure the voltage at the battery posts. Here's a chart to correlate resting open-circuit voltage to

charge state at 68 F:

12.65 v = 100 percent

12.45 v = 75 percent

12.24 v = 50 percent

12.06 v = 25 percent

11.89 v or less = discharged

These specific gravities are highly dependent on the temperature of the electrolyte. I'll leave it to you as an exercise to find the correct voltage at other temperatures. That last 25 percent of charge can't be hurried much by upping the voltage. In fact, the finish top-off charge should be at a leisurely 13.5 to 13.7 volts to keep from damaging the battery and boiling water out of the electrolyte.

But let's give this a fighting chance: What is the voltage at the battery pack when the pedals are being cranked? Some of those old alternators had a set point of only 13.5 to 13.8 volts. A fresh voltage regulator should output around 14.2 volts, measured at the alternator's B+ terminal. Measure again at the battery posts to check for voltage drop in the wiring. Anything more than a half-volt or so difference (while you're pedaling away, of course) should precipitate an upgrade in your wiring. I'd use 10- or even 8-gauge wire, kept as short as possible, and with no intermediate connectors between B+ and the battery positive post. Ditto for the ground: Use a short piece of fat wire and run it directly from the alternator's case casting to the negative battery post. You might pick up another half-volt or so at the battery terminals by carefully reducing the resistance in the wiring harness as much as possible.

Your last resort is an adjustable voltage regulator, which I found easily from several places on the Web, including eBay, for less than 20 bucks. DO NOT adjust it such that it ever delivers more than 14.5 volts at the battery posts. If your battery pack won't deliver enough power to do what you need when it's charged to 75 percent of its capacity, consider adding more batteries. The danger of that is that the electrolyte in a chronically undercharged battery will stratify, with much of the acid collecting near the bottom, leaving a more dilute solution at the top of the plates, reducing the battery's capacity.

You might consider upping the rating

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of your solar panel substantially to provide the proper top-off charge.

Steal This!

Someone was stealing gas from my '07 Lincoln Town Car, so I put a locking gas cap on it. Now the fuel filler and Check Engine lights stay on. Is there a remedy? Will the engine get damaged?

It won't damage the engine. But there is a trouble code being set, specifically one relating to the integrity of the evaporative emissions system, and your car can't pass inspection with it lit. That code is set because your locking gas cap isn't sealing properly. It's supposed to hold a small amount of pressure to keep gasoline vapors inside instead of venting them to the atmosphere. The excess vapors are collected in a canister full of activated charcoal, and returned to the engine to be burned the next time the car is operated.

The remedy is to replace your cap with one that seals properly. Unfortunately, not all locking gas caps are equal. If you bought one hanging on a peg from the auto parts aisle at some mass merchandiser, odds are it isn't the correct one for your car, even if it seems to fit properly. Ford (or in your case, Lincoln) should have one available at the dealership's parts counter. Or try asking at a real auto parts store for a Stant 10510, which should be the correct part for your car. Needless to say, other vehicles will require a different cap to operate properly.

Pinch Protection

My driver's-side window goes up halfway automatically, then goes down all by itself. Then, when I try to close it again, it won't go at all unless I wait an hour.

Those automatic windows have a fail-safe to make them go back down if

they encounter some resistance (like your fingers or, say, the baby's neck) to keep from hurting people. I'll guess the window is encountering some unusual resistance, and is opening back up the way it's programmed to do for safety. Check the window track for torn guides, gaskets, or foreign objects. Spilled your sticky Big Gulp on the window lately? A generous shot of silicone spray on the rubber guides often will clear this up.

What's the wait about? For unrelated reasons, the electric motor has an internal thermal protection circuit so you can't burn out the motor windings by stalling it. This protection automatically resets when the motor cools off after a few minutes.

PM

Got a car problem?

Ask Mike about it. Send your questions to pmautoclinic@hearthst.com or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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As with many aspects of the technology world, there is a modder subculture dedicated to quiet computing. (You can follow their obsessive efforts on sites such as *silentpcreview.com*.) And wherever such subcultures exist, there is a market for products that cater to them. In this case, it means there are plenty of options for lowering your computer's volume. As a side benefit, since the guiltiest noisemakers within a PC tend to be part of the cooling apparatus, much of the same equipment that can hush a computer will also increase its cooling efficiency—and can even shave a few watts off its power consumption to boot.

Before we get to the nitty-gritty tips and tricks, let's dispense with the bad news: Laptops, the most popular kind of computer right now, are so hard to quiet down that it's not worth trying for most end users. A considerable amount of effort goes into engineering laptops that can run quietly, but that is largely a challenge for manufacturers. And the most obvious way of quieting a laptop—using it on top of a pillow—can have dire consequences for the machine's ability to dissipate heat.

Desktop computers, however, are easy to shush. And how quiet you can make your desktop is entirely dependent upon how much money, time and effort you're willing to throw at the problem. So let's tackle the challenge by degrees.

The Easy Stuff

→ **A simple fact** of fluid dynamics: A 120-mm fan rotating at a low speed moves more air than a smaller fan running at top speed. Now consider that inside the average PC there are four to six 80-mm fans hard at work dispersing the heat generated by internal components such as the CPU, chipset, graphics processor and power supply. Keeping the computer cool is a good thing, but your PC doesn't need to sound like it's taxiing down the runway to do it. The PC we selected for our own sound-baffling experiment had a typical configuration, with five 80-mm fans and two hard drives. We measured the noise level at up to 80 decibels (about the level of a telephone dial tone).

The fix for this sort of sonic overload is to simply replace those small, noisy blowers (rated at 32 dBA each) with larger, quieter ones. We swapped out

the fans that came with our computer for a few 120-mm S-Flex fans from Scythe (\$15 each). Not only were these fans larger and slower, but they are built with fluid-dynamic bearings for a smoother spin, which brings the decibel rating of each down to only 8.7. If your fans don't natively run slow, you can dial them down manually by installing a controller module (available from manufacturers such as Thermaltake for around \$25). These typically mount in a 5.25-inch drive bay—such as the one that houses your optical drive—and allow you to turn down the fan speed with the twist of a dial. Just remember to watch your computer's temperature, which you can do with monitoring software such as SpeedFan.

One more note about fans. If possible, it's always a good idea to power them off of motherboard "system fan" plugs, rather than directly off the power supply. By supplying juice from the motherboard, the computer can control the speed of the fans based on its own temperature measurements, instead of simply running them at maximum power constantly.

Bad Vibrations

→ **Ever notice how** your PC shivers whenever the CD-ROM spins up? Spinning components such as optical drives

Ditching Extra Decibels



→ Get Bigger Fans

Replacing small 80-mm fans with larger, slower 120-mm fans goes a long way toward cutting noise and is one of the easiest fixes to do. The old ones screw out, the new ones screw in, and you're up and running in 10 minutes. To adjust speed manually, install a front-panel fan control.



→ Swaddle Your Hard Drive

Spinning hard drives can send vibrations through the case and rattle things that shouldn't rattle. A simple fix is to buffer the screws that mount the drive to the case with rubber washers. Or install your hard drive in an enclosure such as the AeroCool AVN-1000 for total soundproofing.



→ Stick-on Soundproofing

The same stuff that squelches road noise in cars does wonders for personal computers. Dynamat sells cut-to-fit sound-barrier panels that peel and stick to the inside of the PC. Whatever you do, however, don't block any of the air-intake or exhaust vents.



→ Cool Differently

You replaced your whiny fans with quiet ones, and you still hear noise? It's probably coming from the CPU heat sink, which has its own fan. If you're willing to do a little motherboard modification, try liquid cooling. The easiest liquid kits are self-contained, such as the Corsair H50.

Three Things to Know About WiGig

It's really fast.

WiGig, a wireless networking protocol that should show up in equipment this year, is like Wi-Fi times 10. WiGig is based on a variant of Wi-Fi's underlying IEEE 802.11 networking protocol known as 802.11ad, which operates at the very high-frequency range of 60 GHz. But while the fastest Wi-Fi standard (802.11n) maxes out at 600 megabits per second, WiGig has a maximum data throughput of 7 gigabits per second, which puts it on a par with some of the fastest wired networks.

It's not a replacement for Wi-Fi.

WiGig and Wi-Fi are complementary technologies. WiGig doesn't have the whole-house 300-foot-radius range that Wi-Fi does. "It's more of an in-room transmission technology," says Mark Grodzinsky of the WiGig Alliance. So look for equipment that combines the two standards—using Wi-Fi for basic networking, and WiGig for high-bandwidth short hops. Plus, WiGig is designed to make ad hoc (i.e., device-to-device) networking easy and

seamless, so that a smartphone, for instance, could link directly to a computer to upload a movie file without having to join a larger network.

What do we need that kind of speed for?

Good question. Considering that most broadband Internet connections operate in the 1.5- to 20-megabit-per-second range, WiGig isn't going to make Web surfing any faster. But AV equipment will see definite benefits. WiGig can serve as a wireless conduit

for HDMI connections (current wireless HDMI tech is specialized and expensive), moving hi-def streams from Blu-ray players or computers to TVs. WiGig can also enable networked displays, so that any PC in a room can connect cable-free to a WiGig-enabled screen. Still, WiGig is not ensured success—many people already have a wireless-network setup that works just fine for their needs. For them, WiGig's big-bandwidth pipe may seem like drinking out of a fire hose. — GLENN DERENE

and hard drives can communicate plenty of vibration to the computer's case, and that translates directly into sound. There are a variety of options for silencing these shakes and shudders. The 60-second fix is to take a screwdriver and tighten all the screws holding in your drives (loose screws cause the loudest rattles) and apply a drop of rubber cement over the top of the screws.

With our test computer, we opted for a more meticulous solution, relocating the hard drives away from the front of the case, installing silicone bushings under hard-drive screws and placing silicone rubber jackets (like the ones used in iPod cases) over the hard drives, power supply and fans to reduce metal-to-metal contact. A step up from simple dampers is to completely enclose your hard drives inside sound-isolating cases, such as the AeroCool AVN-1000 (\$35). These boxes surround the drives with foam and aluminum (for heat dissipation), making them far quieter. One drawback to this approach: Sound-isolating boxes are too large to fit in standard 3.5-inch hard-drive bays, so you'll need to mount your hard-drive-in-a-box in a 5.25-inch drive bay.

Zero-Tolerance Sound Damping

→ **There's a curious** effort-to-results ratio to PC sound control. Easy stuff such as changing out fans and putting rubber gaskets on drives will take care of 90 percent of your noise. Eliminating the last 10 percent requires considerably more work—but once you go down the quiet-PC path, the quest can become addictive.

With our PC, we decided that a few more steps were appropriate. We applied sheets of Dynamat (a peel-and-stick sound-absorbent foam film that is usually used to kill road noise in cars) to several acoustically vulnerable areas inside our case. The company sells a cut-to-fit PC kit for \$30.

That made a noticeable difference, but when listening closely, we could still hear the whir of the CPU heat-sink fan spinning. The guaranteed way to cut out heat-sink noise and drastically improve cooling is a liquid-cooling system (sometimes called water cooling). Usually, that's a pretty elaborate project, but we made things easy by using Corsair's prebuilt, self-contained Hydro Series H50 water-cooling kit (\$90). The H50 requires a little tinkering with the

motherboard to attach the water block to your CPU, and you have to bolt its small radiator over one of the case fans, but it is remarkably easier than the traditional DIY approach to liquid cooling, which involves cutting hoses and filling the system with glycol.

All of our fan-swapping and vibration-damping efforts reduced the maximum acoustic output to the point where it hardly showed up on our sound meter, which had a low-end range of 50 dBA. Only once, when we positioned our meter within 2 inches of the fans, did we get a reading of 51 dBA (a whisper is generally rated at 40 dBA). That was a level sufficient for us to declare our work complete.

However, for the intellectually curious, it is possible to create a truly noiseless PC. To do so requires using nothing but solid-state drives (SSDs) for data storage and passively cooling all the hot bits (graphics processor, CPU, power supply) with a specially designed case. If you are so inclined, be warned, your obsession will cost you hundreds of dollars in low-capacity SSDs and may require submerging all of your components in a tank of mineral oil. Now that's crazy quiet. **PM**

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Digital Clinic

by Seth Porges

The Future of Call Forwarding

Q Between my work and personal lives, I juggle no fewer than four different phone numbers. Is there a simple way of making it easier to handle all these phones?

A With today's mishmash of land-lines, office phones and personal and company-issued cellphones, people who aren't forced to juggle multiple phones (and multiple phone numbers) have become an endangered species. Google Voice is undoubtedly the best way to manage this mess.

Chances are good you've heard of Google Voice—the service started in 2005 under the name GrandCentral before Google bought it in 2007 and relaunched it last March as Google Voice—but it's amazing how many people ask me just what it is and what it does. Fact is, this is such a complex and feature-filled service that it really isn't easy to explain in a single statement. The easiest approach is to think of it as call forwarding on steroids—a service that takes all incoming calls and automatically routes them to the proper phone (or phones), depending on who's calling.

This lets you cut the numbers you give out down to a single set of digits (a new number that's given to you for free by Google) that you can distribute to anybody. Your boss is calling? Google Voice can forward the call to your work phone. A client? Have the call go straight to your cellphone. Your mother? All your phones can ring, simultaneously.

Awesome? Definitely. I've been using



How Google Voice Works

- 1:** You give everyone you know the same phone number.
- 2:** Depending on who is calling, Google Voice will automatically forward the call to the phone or phones of your choice.
- 3:** Voicemails are transcribed and e-mailed to you for quick viewing.

the service since it first launched, and it's now the only phone number of mine that most people know. The best part: Like virtually every other Google service, it's free—although, as of press time, the service was still invite-only, so you'll need to find somebody else with an

account who can give you an invitation.

The Google Voice magic doesn't end there. Even people who have no interest in consolidating calls to a single number can probably find something useful in Google Voice. For example, Google Voice revives an old answering machine

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PM DIY TECH /// DIGITAL CLINIC Q+A

mainstay that we sometimes miss: the ability to listen in as somebody leaves a voicemail and pick up halfway through the message. It even allows you to transfer a conversation from one phone to another, midcall, as long as both numbers are linked to the same Google Voice account.

Even better is the way Google Voice treats voicemail. The iPhone's Visual Voicemail feature has drawn acclaim for allowing users to instantly pull up and play whichever voicemail they want. Google Voice takes it a step further—not only does it let you play individual messages on demand (either on your phone or through the Web), but it actually transcribes your voicemails and gives you the option of receiving the transcription as an e-mail. (You might say it takes the voice out of voicemail.) For now, the automatic transcription service is very, very far from perfect (it's prone to pretty hilarious mistakes), but it usually gets enough words right that I'm able to get the gist of a message at a glance.

Tricky Trackpad

My netbook has a cramped keyboard that causes my hand to regularly rub up against the trackpad. When this happens, my cursor often unintentionally moves to another point on a document while I'm typing. How can I keep this from happening?

You're running afoul of a feature called tapping, which is supposed to make it

possible to click with a trackpad just by, well, tapping it. Trouble is, it's extremely sensitive and, in my experience, is very prone to mistaking careless palm brushes for clicks—an incredibly aggravating experience when you're trying to type, and one that is often exacerbated in netbooks by the close proximity of the trackpad to the keyboard.

While trackpad tapping is often turned on by default, it's easy to turn off. Go to your Windows Control Panel, click Mouse (yes, we know your trackpad isn't technically a mouse), and look for a setting called Enable Tapping. Depending on your machine, you may also have to click on a menu item called Other Pointing Devices and select your trackpad. Either way, once you find the Enable Tapping setting, disable it. Your problem is now solved.

Macs are not nearly as prone to this issue as are Windows machines (one reason: There are no cramped Apple netbooks yet), but Mac users can still eliminate the problem by clicking on System Preferences, selecting Trackpad and checking the box next to Ignore Accidental Trackpad Input.

PM

Got a technology problem?

Ask **Seth** about it.

Send your questions to pmdigitalclinic@hearth.com or to Digital Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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DOG SLED RACER

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Location: WILLOW, ALASKA
Age: 40
Years on Job: 16

1. DOGS

Ellis's pointer-husky cross produces pups with long legs and more muscle than regular huskies. "The hybrid is very athletic," he says. "A super dog."

2. HARNESS AND LINE

The dogs' Dragrättan harnesses are made of padded nylon webbing that goes around the neck and along the body, ending at the root of the tail. A tug line is hooked to the harness and the Kevlar-reinforced main line. "The lines can be 80 feet long," Ellis says. "On winding corners, you only see half your team. It's exhilarating."

3. SLED

Ellis mashes with the Bewe ALPI-S. Made of aluminum, wood, plastic and carbon fiber, the sled weighs 22 pounds and can hold two injured or tired dogs. When Ellis wants to maintain high speeds going uphill, he runs behind the sled and pushes.

4. CLOTHING

Ellis has gear for weather conditions from 40 degrees F to minus 40, including a down parka and windproof coveralls. Alaskan craftsmen make him heavy-duty mittens (not shown) of beaver fur or moose hide with a sheepskin liner.

5. SNOW HOOK

It's difficult to stop quickly when 10 to 20 dogs are running at an average of 20 mph. Ellis counts on this Norwegian Istind snow hook to act as a parking brake. The 5-pound hook has two steel claws that penetrate the snow, stopping the team and holding the sled and dogs in place.



The world's most famous dog sled race is the Iditarod, an 1100-mile trek across Alaska. But Egil Ellis prefers brutal 20- to 30-mile short-distance races. The Swede is very good at sprints: He and his dogs—a cross between German shorthaired pointers and Alaskan huskies—have won the three-day GCI Open North American Championship in Fairbanks a record-breaking nine times. Racing season runs December through April; the rest of the year Ellis operates a kennel. "You're working with your best friends," he says. "After years of breeding, training and caring for these dogs, you're standing on the starting line of a big race. It's an amazing feeling." — EMILY HAILE