

## THE MAN IN THE MIRROR by GEOFFREY A. LANDIS

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Some of you may think you recognize this problem, but there's an important difference!

It was pure luck that Lynn Rockcross was there. Pure bad luck.

Or maybe not luck at all. Out in the dark, you made your own luck. If the luck of Lynn Rockcross was bad, it was luck he'd forged for himself.

*Ramblin' Wreck* had come out from the inner solar system on a long, constant-thrust interplanetary trajectory. After eight months in space, on their slow approach to Sedna the crew had nearly missed seeing the anomalous landform. It was a perfect circle of pure black. *Ramblin' Wreck*'s crew wasn't being paid to look for unusual things, and really, a twenty-two-kilometer circle wasn't even that unusual. Across the solar system, circles pockmarked the surface of every body, large or small, circles and networks of circles and chains and doodles of circles, craters of every size.

But this one was not just a circle, it was a perfect circle. And on a distant iceball, a world covered everywhere with a thick layer of reddish-brown snow, it was perfectly black.

Who would have expected an alien artifact on Sedna?

Sedna was one of the largest of the objects in the trans-Neptunian belt, a small world nearly the size of Pluto, but in a wildly eccentric orbit, so far away from the Sun as to be forever frozen.

It was the topic of discussion on the *Ramblin Wreck* for about a week as they braked into orbit, between poker games, but the crew chief, Kellerman—a hard-nosed miner with the soul of an accountant—told them that investigating alien enigmas was not the job that the crew of the *Ramblin' Wreck* had come all this way to do, and he was not about to take good time away from the paying job to go look at it. They were miners, not scientists. Sedna was a rich source of organics. Organics could be shipped to any of the colony worlds in the inner solar system. If they could find ammonia as well, they'd have pay dirt. Ammonia was a source of nitrogen, valuable nitrogen, far more valuable than gold or platinum in the built worlds

where every volatile molecule had to be imported. Prospecting Sedna was an economic gamble; it was so far from the Sun that only a huge strike would make it worth paying the amazing shipping costs to send resources inward. But the built worlds were an ever-expanding market, and if they could show that Sedna had deposits rich enough to justify the travel time, Sedna would be a little money mine for the corporation, a slow but steady source of income.

Braking into elliptical orbit around Sedna, they photographed the strange circular anomaly as they scouted for resources, and they sent back to the inner system all the data they happened to gather on its location and approximate size. In return, they were ordered to stay away from it. It was not a natural artifact, they were told, and it most certainly wasn't something humans had built, since they were the first people ever to reach Sedna. It was alien. They weren't qualified to investigate. Back in the inner system somebody worried that a bunch of union-slacker rock jockeys scratching around an artifact of incalculable value would be far more likely to destroy something than they would be to find something valuable.

From their orbital reconnaissance, they had mapped a rich ammonia deposit, a frozen lake of ammonia larger than most asteroids. That, along with the organic tholins frozen into the ice, looked like a good place to start operations.

The mining ship landed on Sedna more than five hundred kilometers around the planet from the artifact, at the ammonia site. Somebody else would be out to investigate the artifact, some slow and careful scientific team, with all the tools and backup from Earth needed. *Ramblin Wreck* was there to mine.

"That's crazy," said Rockcross. "All this way, and we stop a lousy five hundred kilometers from the one tourist attraction on the planet?"

His buddy, Dinky Zimmer, gave him a quizzical look. "We're here to do some mining," he said. "Who cares about a black circle if it doesn't have ammonia?"

Adrian Penn, the third on his three-man crew, said, "If we hit pay ice, with the bonus we're due, we can see all the tourist attractions we want. You want to check my seals?"

Rockcross checked Dinky's suit seals, and then Adrian's, and gave them both a thumbs-up; and then Dinky checked his. The suits were the close-fitting style that the crew called nudie-suits; everybody checked their

own seals, of course, but then for safety they each checked each other as well. The checklist required that every step be verified with a buddy. After seal checks, he verified his suit battery charge, and then checked Dinky and Adrian's charges while they verified his charge. They were suiting up for their first eight-hour shift, taking ice cores and setting up the thermal radiators that would be needed for mining. Someday—if the nitrogen strike was good enough—the equipment they were setting up would be the head of an interplanetary pipeline, where induction motors would toss two-tonne bricks of frozen ices into trajectories that would, over the course of years, coast downhill to markets in the inner solar system. That would be all automated, of course. But for now, humans were needed to scout and set up equipment.

But Lynn Rockcross—known as “Lee” to both friends and rivals—wasn't thinking about his work, although he was paying enough attention to avoid making errors. He wasn't done with the artifact. He had other ideas.

Lee was a shift leader on the *Ramblin' Wreck's* mining operation, responsible for a crew of three. He was qualified on every piece of equipment used in low-gravity and low-temperature extraterrestrial mining operations. He'd been mining and prospecting ever since leaving his home in the domed cities of Vesta, something he had done at fifteen, the age of emancipation in the middle belt. He'd gone first to the ice moon Callisto, and after a little time in a low-paying job on a melt line, had joined the crew on a mining ship. In five years he had worked on four different mining and prospecting ships, earning his union card, working his way up from unskilled labor to shift leader. When he could, he liked to spend his time with wildcat surveys, where he would be dropped off on a likely body with nothing but an augmented suit, a laser drill, and a mass spectrometer. For weeks at a time, he'd be alone to characterize mineral composition in the hopes of a finding a rare strike of usable material. Lee was perfectly comfortable alone in a suit, out of contact with the rest of the universe.

Lee was smart enough in his own way, but he knew that shift leader was as high as he could climb with only his self-education, learning about whatever subject caught his attention. For the long voyage out to Sedna, he had signed up to take university classes, the first step up toward supervisor and eventually running his own ship. Now his personal databot had a load of material for him to study in his spare time: literature, structural mechanics, and physics, to start. Studying should have accounted for his off-shift hours—he had a lot to catch up on—but with the discovery of the strange black circle on Sedna, he was thinking of changing his plans.

The radioed instructions from back in-system, he knew, were more properly a suggestion, not an order. The crew of *Ramblin' Wreck* wasn't subject to orders from scientific institutions a few billion kilometers away.

The union mandated that, even mining high-grade ammonia, they had to be paid triple overtime at hazardous-duty rates for shifts longer than eight hours, and the flint-eyed wretch Kellerman wasn't about to pay overtime. Lee and his crew got sixteen hours off for every eight working, and the union steward watched damn carefully to see that they weren't given unofficial duties in their off time. So he had the time.

They finished their shift, bringing back the ice cores for the cryomineralogy lab to analyze, and Dinky and Adrian headed off to unsuit and hit the showers. Lee watched them head in, but didn't follow.

Lee figured he could skip one day of studying and bypass the after-shift perpetual floating poker game. There was something interesting out there, and he would be damned if he wasn't going to go take a look. Although this was a mining operation, not prospecting, Lee was fully certified for solo prospecting and didn't have to tell anybody what he did in his off-shift hours, if he didn't want to. And so he slipped away, without telling anybody.

The artifact was half a world away, far from the *Ramblin' Wreck's* position near the ammonia deposits. He topped off his suit batteries and then checked a snowcat out of the equipment depot. It was technically theft, maybe, if you looked at it one way, since he wasn't actually on shift, but it wasn't as if he wasn't going to return it—where could he possibly go? He wasn't even using up fuel, since the snowcat had a little nuclear generator that gave out a constant 14.3 kilowatts of power whether it was being driven or not.

That had been his first mistake, going out alone. A few hours later, it was beginning to look like it may have been a fatal one.

The drive was a thrill; a little under three hours at an average speed of almost two hundred kilometers per hour. In the low gravity, the sled bounced up on every little hummock of snow. The first hour he had steered carefully to the smoothest paths, and the bumps had scared him nearly out of his wits. But the sled had attitude control thrusters that kept it from spilling over when it was airborne (or, technically, vacuum-borne, he supposed, since the microbar pressure of mostly-helium surrounding Sedna was nothing that could vaguely be given the nomenclature of air.) After a while he realized the snow pack was so thick, it had smoothed out

the planet's hills into natural ski jumps, and he had gotten more and more adventurous. Now he was picking jumps that gave him a hang time of five seconds, ten, thirty.

A hell of a lot more fun than studying, he thought.

Viewed through his intensity-enhanced goggles, the landscape was low rolling hummocks of a deep, dusky red, the color of Georgia mud. Sedna was beautiful. Lee saw a landscape of soft hills lit by urgently brilliant stars, speckled in colors: the glistening white of water-ice snow splashed across through scars in the surface of red tholins. He tried switching the image intensifier off. At first all he could see was darkness, and the sense of speeding across darkness, trusting in the autopilot to avoid obstacles, made his heart hammer. After a minute he began to make out the smudges in the darkness, and in a few minutes more, even though the sun was billions of miles away, he discovered that he could still see. Without the image intensifier, the surface was colorless, a pale ghostly glistening in the starlight, with the Sun so small he could have covered it with the head of a pin.

It seemed more real to him this way, so he left the image intensifier off. The heads-up display told him the topography, and the autopilot picked out the smoothest path across the snow.

"You guys should have come with me," he said, speaking to the empty air. "Poker's no fun, not until after payday, anyway."

He was lucky he didn't sled right into the artifact. He'd been having such a good time hot-dogging the snowcat, he'd stopped paying attention and had lost track of how far he'd come. Fortunately his navigation computer hadn't, and warned him when he was approaching the artifact.

Once cued to look, he could see it: in the distance, the horizon cut off abruptly. Lee flicked the image intensifier back on, and suddenly it was impossible to miss, a sharp black line across the red horizon. He slowed down to approach it cautiously, edging up to the razor-sharp edge between the snow and the black, and finally getting off the snowcat and creeping forward slowly.

He looked down.

The black was speckled with stars.

For an instant he thought it was a hole straight through the planet, and

then he wondered if it could be a portal to another universe.

Lee anchored the snowcat and clipped a safety tether to it. His toolpack carried all his gear, but carrying the pack made it too awkward for him to bend over, so he took it off and wore only the skin-tight nudie suit. Making sure that his tether was secure, he kneeled down at the edge and leaned over to look down.

He saw a golden helmet faceplate—his own faceplate—looking up at him.

The black surface was not black at all, but a gargantuan mirror reflecting the blackness of space, angled steeply away from him. Close up, he could see the sharp image of stars reflected in it. He was so close to it that it seemed perfectly flat, but looking across in the distance he could see the subtle curve.

He put his hand on it (the mirror-image hand coming up from below to touch his), and it was perfectly smooth and perfectly slick. Absolutely smooth, slicker than oil, as if he was touching nothing, no resistance at all to him sliding his palm across the surface.

Through his glove he couldn't sense the temperature. His suit was a near-perfect insulator; it had to be, of course, to operate in the outer solar system, where the miners walked the cryogenic ice fields of trans-Neptunian and Kuiper objects.

Lee checked the external temperature meter on the fingertip of one glove. Pressing his finger to the mirror's surface, the gauge read five Kelvin. The reading was so unlikely that he pulled his hand away to try another spot. The next spot was still five Kelvin, as was a third spot, and a fourth.

“Sonnabitch,” he said. “Colder than a loan shark's heart.”

His meter wasn't broken; he checked a patch of the crusty snow surrounding the pit, and got the right number, thirty Kelvin. The surface of Sedna was colder than the caves of hell, but the temperature of the black surface was twenty-five degrees cooler yet, far lower than it had any right to be.

Slowly, he worked it out. The surface was not black; it was reflective, and only appeared black in that it was reflecting the starry sky. It must be very close to a perfect mirror indeed. Far as they were from the Sun, the

snows of Sedna still absorbed sunlight, and that heated them a few degrees above absolute. But this perfect reflector must absorb no light at all and stay cold. Somewhere in the far infrared, it must radiate away a tiny amount of heat, he realized, but in all the wavelengths in which the Sun shone, it absorbed nothing, and so was colder than the surface it sat on.

It was an enormous concave mirror. A giant telescope, miles in diameter—built for what purpose?

Lee stared out across it, marveling. It showed no signs of age, but certainly it must be ancient. Who had made it, and when? Sedna was one of the more eccentric objects in the solar system's Kuiper belt, a dwarf world in a long slow orbit that took it to a farthest point nearly a thousand astronomical units from the Sun, barely bound to the Sun at all. Probably it had once been an interstellar wanderer, captured by the Sun millions or even billions of years ago from the cold darkness between the stars. Where had it come from? What unknown race had built such a gargantuan telescope mirror, and for what purpose?

He leaned over to put his faceplate right against the mirror surface, steadying himself with one hand carefully wrapped around the taut safety line. The surface was perfectly smooth, perfectly reflective.

And suddenly the line was slack.

He stood up and saw the snowcat looming toward him in the darkness. He had anchored the cat against a hummock of ice, but waste heat from the reactor had melted it free, and it lurched downhill now, staggering drunkenly toward him. Without thinking, he took a step back away from it.

He realized his error instantly. His cleated boots found no purchase, the surface of the mirror slicker than ice, and his feet shot out from under him. He reached out wildly as he fell. In the low gravity, everything happened in slow motion. With one hand, he grabbed onto the toolpack he had set down on the edge. For a moment he hovered there, on his belly, his feet dangling down the slope of the enormous mirror, hanging on with his left hand clutching the toolpack on the edge of the slope, the right still clenched tightly on the now-slack safety line.

The snowcat slid forward, bounced against a ripple in the ice, toppled over onto its side, and ground its way to a halt with a silent spray of crimson snow.

It rocked a little and then settled into place.

It seemed stable. Very slowly, trying not to move, he gathered up the slack in the safety cable and gave it a very careful tug. The snowcat stayed firmly in place. Working one-handed, he fixed the cable onto his belt clip.

Gravity on Sedna was minuscule, less than a twentieth of a standard Earth gee, and it would be easy enough for him to pull himself out of the pit, even one-handed. He relaxed for a moment, the danger temporarily at bay. His left arm was getting stiff from the awkward position holding onto the toolpack on the rim, and he shifted it minutely.

The pack that anchored him broke loose from the snow.

In gloriously slow motion, the toolpack, and Lee, slid down onto the mirror. He flailed for the lip of the pit, seeking anything he could grab onto, but ended up with only a handful of snow. In the process he released the toolpack, and it slid away down the slope, spinning slightly and gathering speed as it slid.

The safety line was still clipped to his belt, the other end attached to the snowcat. He slid down into the mirror, and when the slack in the safety line had played out, it caught with a jerk, stretching slightly, but held. Above him, at the other end of the rope, the snowcat shuddered slightly, but didn't move, stuck in the ice. He was swinging at the end of the line. He stretched out his arm, but the rim was just out of the reach of his outstretched fingertips. With one hand, he reached out and grabbed the rope to pull himself up.

And the clip broke.

The line whipped away from him, sliding through his fingers as if it had been greased, and with a slow, easy grace, Lee Rockcross slid down the frictionless surface of the mirror.

As he slid, he tried to scramble up the side of the slope. The rim of the dish was only inches away, but despite his frantic flailing he could get no purchase at all, and he coasted smoothly down, gathering speed at a slow but inexorable pace. It was maddeningly frustrating.

I screwed up, he thought.

Sliding down the mirror, he had time to contemplate his life, and the ports he had visited, and his sins, both the ones he had accomplished, and



the ones he hadn't gotten around to yet. All of them seemed petty and meaningless.

All that took him about twenty seconds, as he slid, face down, still scrambling against the surface with a futile, reflexive motion.

After a while he gave up. He twisted around and with some amount of effort managed to sit up. Moving on the frictionless surface was like moving in free-fall, and he'd had plenty of experience with that. By working on it for a while he managed to get the hang of it. He windmilled around until he was facing almost in his direction of motion, took stock of his situation, and tried his best to calm himself down. The emergency protocols had been drilled into him, and he chanted them silently like a mantra.

*Protocol for an emergency: First, take whatever immediate actions are needed to prevent the situation from deteriorating, and compartmentalize the damage.*

Well, that was simple. He was sliding down toward the bottom of a mirrored pit, and there was nothing for him to grab onto. There wasn't any way the situation could get much worse.

*Second, activate dual-band emergency locator beacon on broadcast channels 121.5 MHz and 406 MHz.*

The snowcat, already out of sight above him, had his emergency beacon, along with the rest of the long-range com gear. The spare emergency beacon was in his toolpack, sliding along the mirror somewhere ahead of him in the dark

His suit had a low-power ultrawideband link for voice. It was meant for miner-to-miner conversations, but it had been deliberately designed for near-field transmission only; a hundred miners would pollute the radio spectrum otherwise. He recorded a brief call for help, and set the suit-to-suit link to squawk it out in five-second bursts twice a minute. That was a useless task, but at least something he could do to calm himself down. There was no chance it would be heard. *Ramblin' Wreck* was over the horizon, way out of radio range. Since nobody was supposed to be out on the surface, there was no com relay in orbit.

*Emergency protocol, item three: Survey your situation; ascertain your location and velocity relative to possible sources of assistance.*

There were no possible sources of assistance. Still, his suit did have an inertial navigation unit; he could check his location and velocity. He verified that it was on, and brought up his position and velocity in the heads-up display. The dim red figures glowed in his faceplate, floating above the darkness. He was sliding down a slope at an angle just under twenty degrees, currently moving at eighteen meters per second relative to the ground. As he watched, the inertial guidance unit updated his speed. Eighteen point three meters per second. Eighteen point six meters per second.

He had no sense of his speed. Except for the slowly incrementing number in his display, it felt like he was motionless.

That wasn't doing him any good. He had the computer display a plot of his position as a function of time. His path across the surface of mirror was in the form of a perfect paraboloid. That made sense. Of course the mirror would be a paraboloid; it must be the reflector of an enormous telescope. He extrapolated the parabola forward, and plotted his motion as a tiny moving dot. He was moving faster and faster every minute, but his acceleration was slowing down as he headed toward the bottom. Extrapolating from the shape of the curve, he would reach bottom in about four minutes, or just a little over six minutes from when he had slipped off the edge. And then his momentum would carry him up the other side of the slope.

*Emergency protocol, item four: Check consumables. Take action to minimize use of critical supplies until help is effected.*

Lee checked the status of his suit. He didn't have consumables in any real sense of the word. His oxygen supply was a zero-buffer in-line rebreather; every breath he exhaled was stripped of carbon dioxide, which went through an electrolysis cycle that broke it down and immediately recycled it to his next breath. The whole thing was run from a solid-state battery, the same battery that also powered his suit heaters. So it was the batteries that were his ultimate consumable. He checked his battery status: green, at 76 percent full charge. The batteries were sized to run for two full mining shifts plus a little margin, so that gave him a bit over twelve hours of remaining power for life support. Was there any chance somebody would deduce where he was and assemble a rescue before he ran out of power? Unlikely. Nobody would even notice that he was missing until the start of his next shift, which was—he checked the time—another thirteen hours. And even then, it would wait until the end of the shift before somebody would check his quarters to find out why he'd missed work.

*Item five: Appraise resources. Apply the resources available in the most efficient way to effect rescue.*

Fine. His resources were his suit, and—and nothing else, really. Everything else he carried had been in the toolpack he'd lost, or was left with the snowcat. If he'd been wearing a suit for free-space operation, he would have no problem; the maneuvering thrusters would be enough to push him across the slope in any direction he wanted. But the surface suit he wore had no thrusters.

*Item six: When the emergency is over, contact Spacewatch to cancel emergency call for assistance.*

He figured he could ignore that part of the emergency protocol.

Running through the emergency protocols hadn't shown him any way out of this problem, but it had at least damped down his panic. He was now a minute away from the bottom, moving at a hundred and sixty meters a second. He converted that in his head. Vesta, where he had been raised, had been originally settled by Americans, and had stubbornly refused to switch to metric, even after America itself had joined the European Union. He was sliding along at just under a hundred miles an hour. He checked his display again, and noticed that his path wasn't actually taking him quite to the bottom. He would miss it slightly to the left. Right, he thought. He'd been swinging when the clip holding the tether had snapped, and the lateral velocity meant that his actual path was an ellipse—in fact, a Lissajous figure—that wouldn't quite pass through the center. The actual bottom of the mirror would be passing slightly to his right. He inched himself around to look, knowing that it was a pointless move, since there would be nothing to see.

But there was something to see, something gliding silently past. He couldn't quite make it out, until he realized his image intensifier was off, and turned it on.

He was racing past a landscape of dark sand and rocks and a few enormous boulders. It seemed to be just meters away from him, but a glance at his rangefinder told him that this was an illusion, and the rubble field was nearly fifty meters off. The bottom of the mirror was not empty, but was filled with a million years of debris that had fallen into the crater and slid to the bottom.

The suit thermostat was working fine, but he felt suddenly cold. Hitting

that debris field at a hundred miles an hour would have been an abrupt end to all his problems.

The rubble slid past him—or rather, he slid past it—and dwindled behind him. He had reached the lowest point on his trajectory and was rising now, sliding up the slope toward the opposite rim.

He turned the image intensifier off again, to conserve the tiny amount of power it drew. He was now sliding feet first up the slope. He checked his data. At the lowest point of his slide, his maximum speed had not quite hit a hundred and seventy meters a second, and now he was decelerating as the slope steepened and he slid up toward the opposite rim. He leaned back to think, and caught a glimpse of the sky.

Even with no enhancement, the sky was spectacular. There were stars below him, and stars above him, and it seemed as if he were gliding on a perfectly transparent sheet of ice through endless space. The sun was a speck of fire, so bright that it almost hurt his dark-adapted eyes, and yet so small it shed nearly no light. When he averted his vision, he could see that it was surrounded by a ghostly disk, so faint as to be little more than the memory of a glow, the zodiacal light. And surrounding that were stars in their millions, fragments of diamond scattered across the velvet of night, glinting in colors from electric blue to a deep brick red.

Lee stared at the stars, running through the emergency procedure list again in his mind. Stop ongoing damage, squawk for help, check location, conserve consumables, survey resources and solve problem, call home.

Step five, that was the hard one: survey available resources and solve the problem. But he still had no resources to survey. His surface suit had no attachments, not even a spare tank of oxygen he might have been able to use as a cold-gas thruster. It protected him from the cold and vacuum, gave him something to breathe, and that was it. Life support and batteries were integral to the suit; he couldn't take them out even if he wanted to. And everything else was in the miner's toolkit.

Stop, squawk, site, safeguard, survey and solve, and finally call your mother to tell her you're safe.

Survey resources. What about the toolkit? It was sliding across the same surface that he was, with a head start of only a few seconds. It had the tools that might solve his problem—a radio beacon, for one. And, if nothing else, he could use it for reaction mass. If he could hurl it away from him fast enough, he would gain a little bit of momentum to get him to coast

over the rim. It was on the mirror with him, maybe only a few meters away.

Lee twisted himself around until he was sitting upright and snapped his image intensifier on to full. Toolpacks were distinctly colored, to make sure one miner didn't accidentally grab the wrong one, and his was a bright lime green. It took him only a few seconds to spot it. There it was, no more than twenty meters ahead of him, spinning slightly as it slid.

In fact, since it was ahead of him, it would reach the far lip of the bowl before he did, turn around, and come right back to him.

According to the graph he had made in his display, the rim was about a minute away. He fixed his gaze on the toolpack sliding ahead of him, ready to grab it as it slid back toward him. Yes. There it was, right up at the edge—was it actually going to fly up over the edge and out of the bowl? It just kissed the edge, slid toward the left, and then started gliding back down toward him.

He was slowing down as he rose toward the edge, and the toolpack was speeding up as it fell. He stretched toward it, spread-eagled across the mirror, but the toolpack slid past well outside the reach of his outstretched fingers.

But he had no time to cry out over missed chances. In another moment the edge of the mirror approached, and he clambered across the mirror's surface on all fours, stroking like a swimmer. If he could just gain even a single meter of altitude...

To no effect. The edge hovered ahead of him, tantalizingly close, tantalizingly out of range. All his effort hadn't gotten him a millimeter closer.

The rim disappeared in the distance, as he gained speed back downward.

Why hadn't the pack come back to him? It was that elliptical motion, he realized. The toolpack was orbiting the center of the mirror, just as he was, sliding in an ellipse that didn't intersect his trajectory.

He was sliding back down now. Six more minutes to the bottom, twelve to the other side. And then another twelve minutes down again, and back, and back ... until his battery died and he froze and suffocated. And after that, how long would his body continue oscillating? Days? Years? The mirror couldn't be perfectly frictionless; nothing in the universe was perfect. If it was perfect, the rubble wouldn't be there in the center; the rocks that fell

in would still be oscillating.

He was the bob on a pendulum, he thought, with a frictionless surface instead of a rope. For a moment his thoughts took him back to his childhood, growing up on Vesta. He and his brother had competed with each other on the swings, seeing who could go higher. They must have tried a hundred times to swing so hard as to go all the way around, over the bar. They never succeeded, even with Vesta's low gravity making it easy; when they barely got higher than the pivot point, the rope would go slack, and the swing would fall with a jerk.

Thinking about the past wasn't going to help him, and he forced his thinking back to his present situation. In a few minutes he would be back to his starting point. What about the safety rope? If it was still dangling down—but it wouldn't be. He replayed his fall in his mind. The safety rope had snapped back like an elastic band when the clip broke, and disappeared over the edge. He would try to grab it, if it was in reach, but he wouldn't count on it.

It wasn't. He slid up, frustratingly close to the rim, and for a moment he seemed to hover with the rim just out of reach, and then slid away. The toolpack hadn't come any closer to him this time than it had on the opposite rim, and the rope was nowhere in sight.

But here was something else to think about. Sedna rotated once every ten hours. In—he checked the time—two hours, the sun would be overhead. In the cold dark a hundred astronomical units from Earth, the intensity of the Sun was dim, but what would happen when it was focused by a mirror twenty kilometers in diameter? In fact, that was very likely the purpose of the mirror, he realized. It wasn't a telescope; it was an enormous solar furnace.

But he wasn't thinking. The mirror might focus sunlight to a high concentration indeed, but that would be miles overhead, at the focal point of the mirror. On the surface of the mirror itself, the sunlight would be no brighter, and no less bright, than any other time. It was freezing he had to worry about, not frying.

Passing the bottom of the mirror. Lee clicked his image intensifier on again, watching the rubble in the center, trying to think of a way to make use of it. But it was still fifty meters away. Nothing useful there.

He clicked it off, and he was surrounded again by a world of stars and darkness.

Should he go back to reflecting on his life? Swinging with his brother, that was a good time, even if they never did make it over the bar. He could spend the remaining few hours remembering good times. The thing about being a prospector, he thought, is that you see a lot of places, but you only see the backsides, the seedy sides, the places in town near the dockyards. And they all look the same. He knew miners with a girl on each rock-town they visited, but no matter whether the deal was explicit or implicit, one way or another they were strictly pay propositions. He made good money, when he was employed, but somehow he never really managed to save any of it. It wasn't that he was wasting his life, not exactly, he thought, but there had been enough of it already. It was time for him to move on. He needed to study, finish a degree, make something of himself.

Well, he had plenty of time to study, if that was what he wanted to do. Not that it would do him much good—he was trapped in a bowl. But that reminded him, he did have one resource that he hadn't thought of. His personal databot had a load of study materials, and one of his subjects was physics. What if his problem had a solution somewhere in the physics texts? It was a long shot, but why not try?

He booted up his study material, and put in search text: "PROBLEM, SLIDING ACROSS AN ENORMOUS MIRROR." He had no real hope that anything would come out, but the search gave him one hit.

Astonishingly, the hit was in literature, not physics. The link was to the twentieth century, an ancient science fiction story that had two men sliding on the surface of a frictionless mirror. He'd always hated classic science fiction. He'd read enough of it in school, before he'd dropped out. The teachers all seemed to love it. But the old authors had always gotten everything so wrong. The characters did amazingly dangerous things, with no safety backups; they were uniformly too stupid to live.

Things like stealing a snowcat to drive across an alien planet, without telling anybody where they were going? Well, it has seemed like a good idea at the time.

The databot didn't have the text of the story, only a brief summary in a survey on twentieth-century literature. He scanned through it. It wasn't quite his situation, he realized with mounting disappointment: the characters in the story had far more resources at their disposal. In the story, the two characters were roped together, and they used that fact to pump up rotational speed to allow them to fly apart. The discussion went on to say how the solution in the story wouldn't work; the author had ignored

conservation of angular momentum. No help! Lee would have thrown the book away in disgust, if it had been a physical book and not just a glow in his heads-up display.

If only he had a book to throw away! Or anything at all. He could have used the momentum. It was exactly like being adrift in space without a pack. He had no control over his motion.

See related terms, the summary said. *Simple harmonic oscillator. Frictionless motion.*

He queried simple harmonic oscillator, saw that it seemed to be a tutorial about sines and cosines, with no obvious application to him, and then flicked over to frictionless motion and scanned the tutorial. Superfluid helium, it said, was the only substance known to support frictionless motion. Well, that was interesting. Could the aliens have found some way to solidify superfluid helium? No, that was ridiculous. But, still, the surface of the mirror was desperately cold, cold enough to make even God shiver. Maybe the mirror was made of some substance that had a thin film of superfluid helium on the surface? Could he possibly heat the mirror and destroy the effect?

But no, that was a dead end. Even if it weren't frictionless, the surface would still be far too smooth for him to be able to climb the slope to the rim. He'd have to carve steps into the slope, and he had no tools to do that. Did the material have any give at all? He kicked at it as hard as he could, but it was like kicking solid granite. His toe hurt, even through the boot, but there had been not the slightest give to the surface. Whatever material it was made of, it was hard.

A frictionless surface probably had commercial value, even if it only worked when it was cooled nearly to absolute zero. If that bastard Kellerman just knew that one of his workers was slipping along the surface of a material more valuable than any ammonia on the planetoid, rescue would be here soon enough.

That line of thought didn't bring him any closer to rescue.

The rim approached, or rather, he approached the rim. He slid toward it, slowed, hovered frustratingly short of the edge, and then dropped away. Lee checked that his radio was still broadcasting the useless call for help; verified that the toolpack was still out of reach, checked his battery status. No help, no help, no help.



He was sliding down the slope on his stomach, like riding a sled. He twisted around and then carefully pushed himself up onto his hands and knees. He pushed upright, balancing on his knees, with one hand on the slippery mirror for balance. Wobbly, but after a while he could keep his balance. That wasn't too hard. He tried getting up onto his feet, and made it for a moment, his arms windmilling desperately to keep his balance before his feet shot out from under him.

It was like trying to stand on ice. He worked at it and eventually found his balance. It was a lot like snowboarding on the hills of Callisto, he realized, or skiing the polar caps of Mars, something he'd tried once on shore leave. The carbon dioxide snow of Mars was nearly frictionless, too, but if you stayed loose and alert, you could stay vertical. The trick was to keep his center of gravity above his feet. It was a matter of holding his arms out, keeping his knees bent, and making continuous sliding adjustments. The low gravity worked in his favor, giving him time to correct.

He stood, surfing down the slope. If only his brother could see him now!

It did nothing to help his situation, but just being able to stand gave him a tremendous feeling of accomplishment, as if he were now in control of his environment. He imagined himself an Olympic ski champion, gliding down the run of artificial snow on the slopes of Olympus Mons. He checked his display: almost to the bottom and heading uphill again, he was racing at 150 meters per second. That must certainly be breaking all ski records! He raised his hands in triumph to the imagined cheers of thousands—and skittered backward, landing on his butt.

In a tenth gee, falling down was no big deal. Lee twisted around and tried again, and with practice found he could stand almost without conscious effort.

As if being able to stand up would do him any good.

Or would it? Wait, if he could stand, couldn't he jump? In a tenth gee, he ought to be able to jump pretty high. Wouldn't there be some way he could just jump that tiny distance from the top of his trajectory to the rim?

With a little practice, he discovered that indeed, he could push himself off the ice hard enough to get momentarily airborne. It took concentration and a lot of coordination to actually jump, instead of just having his limbs flail out in all directions across the ice. (Not ice, he thought. Mirror. It's not really ice.)

But as quickly as his elation rose in him at the sudden hope, it drained away. Being able to jump didn't do him any good, because he could only jump straight up. No, not even straight up—he had no traction at all, so he could only jump in a direction exactly perpendicular to the surface of the mirror. He called up the picture of his trajectory across the mirror in the heads-up display and stared at it, trying to see a flaw in his reasoning. Suppose he jumped right at the moment he reached his highest point. But the slope of the mirror was the wrong direction; he'd actually be jumping away from the rim. No help. If he jumped a little early? No, still no good; he'd always be jumping the wrong direction.

He drew himself a little diagram in the heads-up display and put an icon of a man in a spacesuit on it. Any way he studied it, though, he couldn't see a way that jumping was going to help him. In fact, it even hurt him—if he could add just a little bit to his velocity toward the rim, he could make it, but his jumping added velocity away from it.

Or, wait, was that right? His jumping would actually be perpendicular to the way he was moving. So it wouldn't change his velocity along the mirror. Or would it? He wished he understood the physics a little more. The mirror was curved. It sure looked like there ought to be a way to make this work. His jump was a vector, and there had to be some way to make that vector work in his favor. But he couldn't see it. It was too complicated for him

*Appraise resources available and apply them to solving your problem.* His resources were himself, the child on the world's biggest swing set ... and a databot tutorial about physics.

He flicked back to the tutorial, searching through screen after screen explaining simple harmonic motion. That was his situation, he saw; sliding in a parabolic potential well. But nothing in the tutorial discussed pushing off in the third dimension. It explained that his motion followed a perfect sinusoidal curve—he knew that already—and that the period of oscillation was constant, a fact that didn't help him any. Then the tutorial went on to cover the case of driven oscillators, when there was an external force pushing in time with the oscillation. Even a very small force, if he could apply it in phase with his motion, would quickly increase the amplitude of his motion. Even a small force—he wanted to scream at it. That was the problem! He didn't have a small force, and the tutorial wasn't giving him any clues. Instead, it wanted to tell him about kinetic and potential energy.

When in doubt RTFM, he thought. Read the fancy manual. A hundred

times he'd gotten that advice, although sometimes the adjective used was something other than "fancy." And the tutorial on simple harmonic motion was the only manual he had. If the answer was anywhere, it had to be there.

He started in on the chapter on harmonic motion, reading from the beginning, working the problems, single minded in his approach. Once he looked up, checked the heads-up display, and realized with a shock that over an hour had gone by, three full oscillations, while he hadn't been paying attention. With his attention fully engaged, the material was interesting, he thought, worth studying just for its own sake. He could suddenly see why physicists were so passionate about their work. The solution had to be there, it had to be hiding somewhere in the mystery of kinetic and potential energy.

And it was.

He almost laughed when he finally saw it. It was the swings.

He needed to get serious. He checked his display and realized that he had been studying the physics text for over three hours. The Sun had set. While he hadn't been paying attention, he had made eight trips across the mirror and back. He checked his power level; about nine hours of battery life left. But he had the sequence worked out in his head.

He was lying on his back, sliding downward, so the first thing was to roll over onto his belly. He called up the graph of his position and velocity, watching his progress in the display, and as he approached the bottom, he got ready by pushing himself onto his hands and knees. When his velocity reached maximum, at his lowest point on the pendulum swing, he got up onto his feet.

That was it. That was his plan.

It was a trick to stay upright on the slippery surface for the twelve minutes it took him to slide toward the rim. When he was vertical, he'd raised his center of gravity by perhaps seventy or eighty centimeters. Not a lot.

The rim approached. Standing, he could now see over the rim onto the snow-covered plains, even though he was tilted significantly away from the edge. The snowcat was nowhere to be seen.

Still, though he could see outside the bowl, the surface beyond was still out of his reach. No matter. As he coasted to his momentary hover just

short of the rim, he implemented the next phase of his plan.

He sat—or, rather, allowed himself to fall down—and then pressed himself down against the surface of the mirror, trying to squeeze himself as flat against the surface of the mirror as he could manage.

That was it. A small change in center of gravity, but—he hoped—if repeated enough, a significant one. Every time he passed the bottom of the bowl, he raised himself up—at each rim approach, he lowered himself down. It was like pumping a swing; each time he was pushing just a little bit of energy into his motion. Whenever he crossed the bottom, by raising himself up he moved his center of gravity just slightly toward the invisible pivot point of the swing, and his speed increased infinitesimally. When he lowered himself at the rim, he was hardly moving, and so he lost nothing. Each cycle, he would gain just a little energy.

Another cycle: stand at the bottom, drop at the rim. Again. Again. Was the rim closer? Hard to tell. Again. Again. He allowed his mind to go blank, concentrating on nothing other than his moves. He was back on Vesta, back on the swings with his brother, trying to pump the swings enough to race his brother to take the swing up over the bar. Again. Again.

Now the rim definitely was closer—as he dropped down, he stretched his arm out as far as he could, and his fingertips touched snow. Not enough to get a grip, but still, progress. He tried to pull himself up by one fingertip, but no success.

Down. Up.

Again, a little closer; this time he got two fingertips over the rim, and he pulled as hard as he could. Again. Again. Now he could get his entire palm over the rim, and he pushed down with all his strength, pulling himself up and almost succeeding in getting his elbow over the rim before he slid away.

On the next slide, he had both his hands over the rim, he pulled himself up to his elbows, pushed up, then flung his knee up over the edge, teetering for a moment and then flopping awkwardly out onto the rim, onto the surface.

He was out.

He was on the surface, spread-eagled in the snow, and wasn't even breathing hard. It had been easy! "Physics," he said. "It's all in the physics."

He crawled away, not trusting himself to stand, putting a few meters between himself and the treacherous edge. He checked his power. Almost an hour of battery left, but that was plenty. As soon as he got to the snowcat, he could plug into the cat's power supply. And the cat was—

The bottom dropped out of this stomach. The cat was nowhere near.

He checked the inertial navigation system in his display, disbelieving the figure it was telling him. The cat was twenty kilometers away!

The display showed his position relative to the snow cat clearly. He'd come out on the wrong rim.

He sat down on the snow and checked the display again, and then once again, trying to make it come out right by concentrating. How could he have made such an elementary mistake?

The cat was on the opposite rim, but not precisely across from him. During the hours that he had been sliding across the mirror, the planet had rotated under him. He'd come out on the same side he entered from, but the planet itself had moved. The snowcat was about a 150 degrees around the circumference. That was better than having it be exactly on the other side—it would be only twenty-nine kilometers for him to walk around clockwise, a little less than the full thirty-five kilometers around the rim.

But twenty-nine kilometers might as well have been a thousand, or a million; there was no way he could walk that far in the remaining—he checked his display—fifty-two minutes.

He lay back, suddenly exhausted. How long had he been awake, anyway? He could just go to sleep—

That wouldn't get him anywhere. He sat up again, the emergency protocols played in his mind like a mantra. *First, take whatever immediate actions are needed to prevent the situation from deteriorating....*

He stared out at the black mirror. He visualized where the snowcat must be, on the far rim of the bowl, invisible in the darkness.

*...Item five: Appraise resources. Apply the resources available in the most efficient way to effect rescue.*

The resource he had was one frictionless bowl, perfectly black,

perfectly smooth, perfectly frictionless.

It was the last thing he ever wanted to do, but waiting and thinking wouldn't help; all it could do was to delay him, and maybe he would lose his courage. It had to be done now.

He stood up and walked away from the rim, then turned and fixed his eyes on the edge. There it was.

It was the laws of physics again. He had been trapped in the mirror because he had entered it with insufficient energy to get out again. All he had to do now was go straight across, a little bit to the right, but of course he would have to aim further to the right, compensating for how the bowl would shape his motion into a curve. As long as he had enough energy, as long as he entered with enough speed, the mirror would be no trap. If he ran into the mirror, instead of allowing himself to fall, he would come out again.

It was physics.

His hindbrain was screaming to him that it was suicide, but there really wasn't a choice. There never had been. He got a running start and dove into the mirror.

His dive took him on a long flat curve, and in the low gravity he seemed to hang in space, the blackness below him mirroring the infinite depths of space above him, weightless in his arc for a moment that seemed like forever.

And then he hit the surface of the mirror, sliding, sliding. In his helmet, the display showed his trajectory, projecting his motion across the mirror.

But he wasn't paying attention. He knew his trajectory was right. He could feel it.

At last, when it counted, he had made it over the top.

—*for Ross Rocklynn*