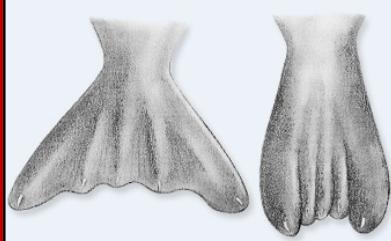


Flippers



Resource – Actuation

*'The time has come,' the walrus said,
to talk of many things.'*

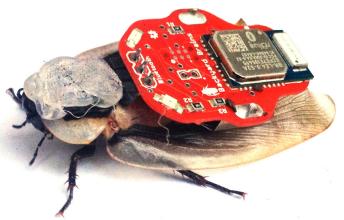
Vacuum Gripper



Resource – Actuation

*Where the bee sucks, there suck I;
In a cowslip's bell I lie.*

Cyber-Cockroach



Resource – Actuation

A biological cockroach with implants for computer control.

Any foolish boy can stamp on a beetle, but all the professors in the world cannot make a beetle.

Weasel Ball



Resource – Actuation

Methinks it is like a weasel.

Pheromones

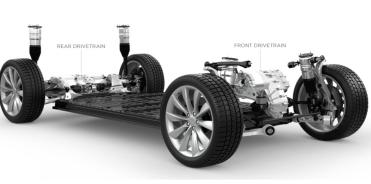


Resource – Actuation

An emitter of artificial pheromones.

*How full and rich a world theirs to
inhabit is—Sweet scent of grass and
bloom.*

Tesla Model X Chassis



Resource – Actuation

*Today's scientists ... wander off
through equation after equation, and
eventually build a structure which
has no relation to reality.*

Segway Base



Resource – Actuation

*Life is like riding a bicycle. To keep
your balance, you must keep moving.*

Speaker



Resource – Actuation

*A sound so fine, there's nothing lives
twixt it and silence.*

Differential Drive



Resource – Actuation

A platform with two independently-powered wheels.

*Change does not roll in on the wheels
of inevitability, but comes through
continuous struggle.*

RGB LED



Resource – Actuation

The rainbow comes and goes, And lovely is the rose.

RC Car Chassis



Resource – Actuation

I would have nobody to control me; I would be absolute: and who but I?

Finger



Resource – Actuation

"When the finger points to the moon, the student looks at the finger."

Christmas Lights



Resource – Actuation

Not a creature was stirring, not even a mouse.

Tracks



Resource – Actuation

One woe doth tread upon another's heel.

Circular Saw



Resource – Actuation

I don't think so, Tim.

Legs



Resource – Actuation

A pair of humanoid legs.

A traveller at Sparta, standing long upon one leg, said to a Lacedæmonian, 'I do not believe you can do as much.' 'True,' said he, 'but every goose can.'

6359.90 USD

DC Motor



Resource – Actuation

Have power, will rotate!

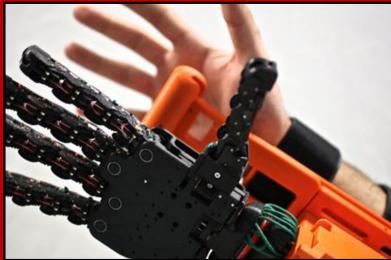
Pair of Wheels



Resource – Actuation

The wheel is come full circle.

Hand



Resource – Actuation

With one hand he put a penny in the urn of poverty, and with the other took a shilling out.

Cheap Pan-Tilt Kit



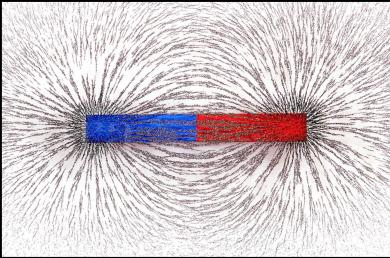
Resource – Actuation

A cheap pan-tilt kit made of two HiTec servos (HS-422) and two Lynxmotion servo brackets.

Do you see over yonder, friend Sancho, thirty or forty hulking giants? I intend to do battle with them and slay them.

29 USD

Bar Magnet



Resource – Actuation

0.01 Tesla of pure magnetism.

Are you a firm believer in miracles?

Linear Actuator



Resource – Actuation

Creates motion in a straight line.

Straight down the crooked lane, and all round the square.

High-Quality Pan-Tilt Kit



Resource – Actuation

This professional pan-tilt kit can move a payload of up to 10 kg.

'Take care, sir,' cried Sancho. 'Those over there are not giants but windmills.'

8.5 lbs; 1,199.99 USD

Balloon



Resource – Actuation

Would you like to ride in my beautiful balloon?

Tentacle



Resource – Actuation

Talent without discipline is like an octopus on roller skates.

Puppetry Wires



Resource – Actuation

I know what I look like—a weird, sad clown puppet. I'm fine with that.

Propellers



Resource – Actuation

A pair of propellers. They convert rotation to thrust.

If the young person ... has poetry in him or her, to offer them help is like offering a propeller to a bird.

Steerable Needle



Resource – Actuation

If you don't like what you're doing, you can always pick up your needle and move to another groove.

300 Duckies in a Bag



Resource – Materials

Anything to declare?

Standard Duckie



Resource – Materials

Giant Rubber Duckie



Resource – Materials

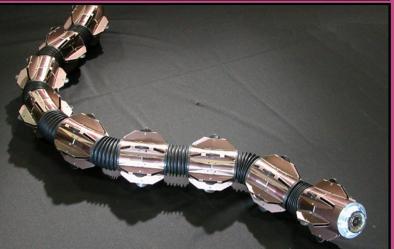
Titan XIII



Resource – Platform

The newest sprawling-type quadruped robot from the Hirose/Fukushima laboratory at Tokyo Institute of Technology.

ACM-R5 Amphibious Snake



Resource – Platform

Snake robot from the Hirose/Fukushima laboratory at Tokyo Institute of Technology.

Now the serpent was more subtle than any beast of the field...

Baxter



Resource – Platform

A robot designed by RethinkRobotics.

25,000 USD

Youbot



Resource – Platform

Omnidirectional mobile platform with 5 DOF arm, designed by KUKA.

30,000 USD

Gimball



Resource – Platform

A flying robot that can survive impacts with the environment, designed by Floreano (EPFL).

R2 Astromech Droid



Resource – Platform

The popular series of astromech droids manufactured by Industrial Automaton.

"An extremely well put-together little droid."

Dragon Runner

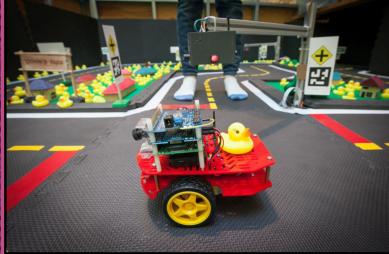


Resource – Platform

A compact remote-controlled robot used by the British army, designed by CMU.

20 lbs; 120,000 USD

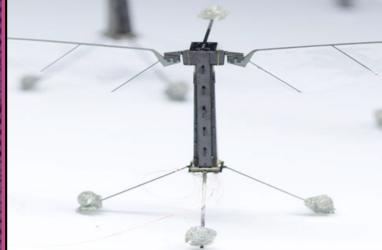
Duckiebot



Resource – Platform

A low-cost educational platform.

Robobee



Resource – Platform

A miniature robotic insect, designed by Wood (Harvard).

PR2

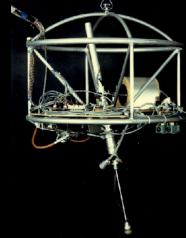


Resource – Platform

The PR2 has two 7-DOF arms with a payload of 1.8 kilograms, and an omnidirectional base.

280,000 USD

3D Hopper



Resource – Platform

The 3D Hopper was created in 1988 by Marc Raibert while at MIT, before he left to found Boston Dynamics.

Good wits jump; a word to the wise is enough.

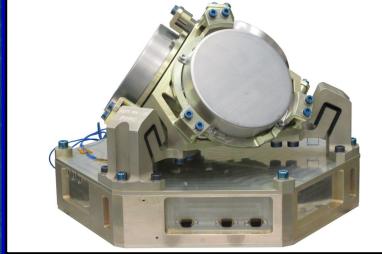
DJI Phantom 4



Resource – Platform

400 USD

Military-Grade FOG



Resource – Sensing

The Astrix 1090 is a 3-axis fiber-optic gyroscope produced by Airbus. It is designed to work for >20 years in small satellites.

12 W; 4.2 kg; 100,000 USD

GelSight



Resource – Sensing

An image-based tactile sensor that works by sensing the deformation of a thin film in contact with the object.

Kinect

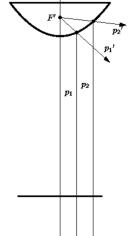


Resource – Sensing

An RGB camera, depth sensor and multi-array microphone running proprietary software, which provide full-body 3D motion capture, facial recognition and voice recognition capabilities.

99 USD

Parabolic Mirror



Resource – Sensing

Turns a camera into an omnidirectional camera.

Sick LMS511 Range Finder

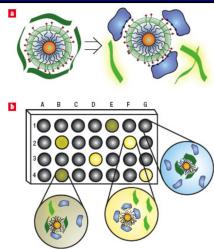


Resource – Sensing

A 2D, 190 deg, range finder with 0.25 deg resolution per ray. The maximum range is 80m.

22 W; 3.7 kg; 7000 USD

Olfactory Sensor



Resource – Sensing

A nose for your robot.

Artificial Ocelli Sensor



Resource – Sensing

Four defocused photoreceptors that can provide enough information to estimate the platform attitude, designed by Fuller (Harvard/UW).

Sonar



Resource – Sensing

Cheap IMU



Resource – Sensing

Uncalibrated accelerometer, gyrometer, and magnetometer.

3.3 V; 9.90 USD

Bump Sensor



Resource – Sensing

Works by measuring the capacitance of twelve electrode points. When an object comes close to the electrode connector, the measured capacitance changes.

30 μ A, 3.3V; 7 USD

Hokuyo Range-Finder



Resource – Sensing

A reliable sensor. Maximum range is 8m.

5 W; 2000 USD

Pressure Sensor



Resource – Sensing

A pressure to voltage transducer.

235 USD

Thermal Imaging Camera



Resource – Sensing

Earth GPS Receiver



Resource – Sensing

Consumer grade, accurate to within a few meters (as long as the robot can see the satellites!)

100 mA, 3.3 V; 25 USD

Compass



Resource – Sensing

Detects the local magnetic field. Unpowered, requires vision system to read.

0 W; 1 USD

Velodyne HDL-64E



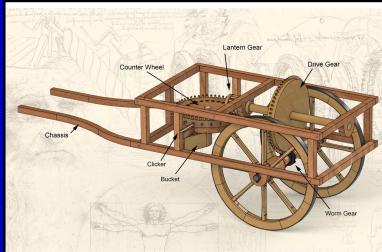
Resource – Sensing

LIDAR, creates point cloud of distance data.

With 2.2 million data points per second output rate, the HDL-64 provides all the distance sensing data you will ever need.

60 W; 29 lbs; 6000 USD

Linear Odometer



Resource – Sensing

1-point Range Finder



Resource – Sensing

Camera



Resource – Sensing

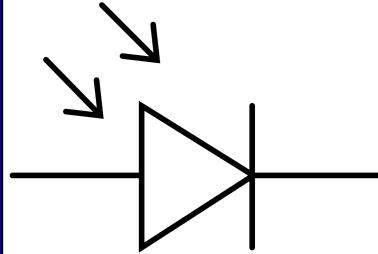
Microphone



Resource – Sensing

250 μ A, 5V; 10 USD

Photodiode



Resource – Sensing

A photodiode is a semiconductor device that converts light into current.

Dynamic Vision Sensor



Resource – Sensing

Rechargeable AA Battery

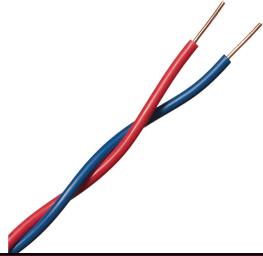


Resource – Power

A rechargeable Li-ion battery.

30 g

Power Tether

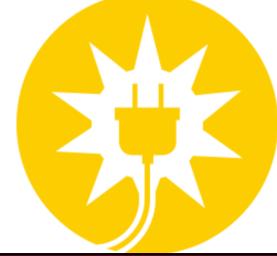


Resource – Power

A 1km long tether supplying as much power as you need (within reason).

+∞ W

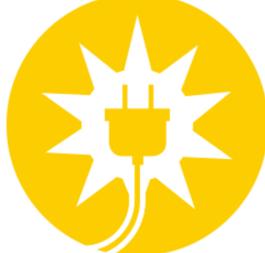
1 Megawatt



Resource – Power

1 MW

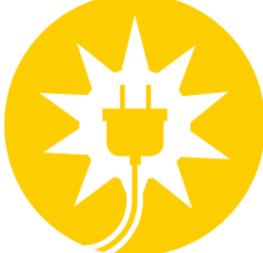
100 Watt



Resource – Power

100 W

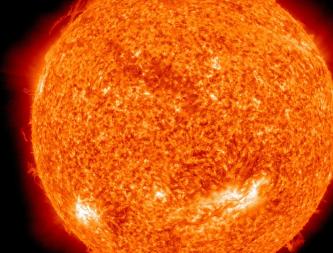
1 Milliwatt



Resource – Power

1 mw

The Power of the Sun



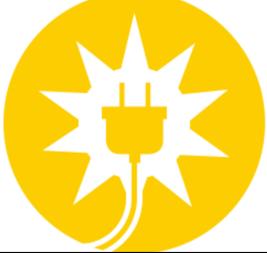
Resource – Power

You can channel all the power irradiated by the sun into supporting your robotic system.

With great power comes great responsibility.

3.828×10^{26} W

1 Watt



Resource – Power

1 W

Pebble



Resource – Memory

A uniquely identifiable landmark that can be placed anywhere and picked up again when that location is revisited.

The rolling stone never gathereth mosse.

640 KB



Resource – Memory

640K ought to be enough for anybody.

Infinite Memory



Resource – Memory

Always remember that you are absolutely unique. Just like everyone else.

Ideal Stack



Resource – Memory

No stack overflow!
The Tower of Hanoi is composed of levels, decreasing in size, variable in number, that we have represented by eight disks of wood, pierced at their centers.

One Bit



Resource – Memory

Memory, the warden of the brain.

Arduino Uno

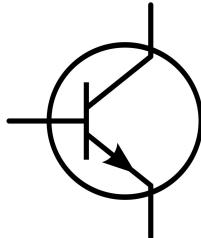


Resource – Computation

I have always loved to begin with the facts, to observe them, to walk in the light of experiment and demonstrate as much as possible, and to discuss the results.

20 USD

Transistor



Resource – Computation

A simple switch.
The complexity for minimum component costs has increased at a rate of roughly a factor of two per year. Certainly over the short term this rate can be expected to continue, if not to increase.

NVidia Jetson TK1



Resource – Computation

Eep Opp Ork! Ah ah! Get in the capsule, baby. We are blasting off.

199 USD

Raspberry PI 2



Resource – Computation

I was working part time in a five-and-dime; My boss was Mr. McGee.

35 USD

Infinite Computation

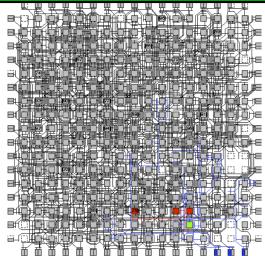


Resource – Computation

You may instantly compute anything for which there is a known algorithm, on any machine.

Infinite riches in a little room.

FPGA



Resource – Computation

Field Programmable Gate Array

Though wisdom wake, suspicion sleeps at wisdom's gate.

100-State DFA



Resource – Computation

States and state transition function are user-defined.

We must accept finite disappointment, but never lose infinite hope.

Macbook Pro



Resource – Computation

Includes all default software and hardware.

Most people have no concept of how an automatic transmission works, yet they know how to drive a car. ... You don't have to understand any of this stuff to use Macintosh.

Oracle



Resource – Computation

Answers a single one-bit question of your choice per second.

I am Sir Oracle, And when I ope my lips, let no dog bark!

The Cloud



Resource – Computation

You have effectively infinite computation...but not necessarily infinite bandwidth.

"Somewhere, over the rainbow!"

TrueNorth Processor



Resource – Computation

The neuromorphic processor created by IBM.

No one ever got fired for buying IBM.

Smoke Signals



Resource – Communication

There is no fire without some smoke.

Communication Tether



Resource – Communication

A cable, with gigabit ethernet capacity, connected to a base station.

Nae man can tether time or tide.

WiFi



Resource – Communication

A network card compatible with the IEEE 802.11ad standard.

I sincerely doubt that the guy who sells socks by the overpass is providing high-speed Internet to the community.

Carrier Pigeon



Resource – Communication

Avian communication channel as specified by RFC 1149.

Every time I feel alone; And slightly blue; That's when I begin to think; It's what I'd like to start to do.

Acoustic Modem



Resource – Communication

This gives you 10 bit/s on a good day.

I'm not asking much. ... What I want from you is your voice.

The Ansible



Resource – Communication

Provides infinite bandwidth at zero latency.

You remember the ansible, the machine I showed you in the ship, which can speak instantly to other worlds, with no loss of years—it was that that they were after, I expect.

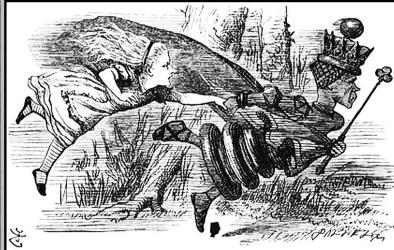
Weak Ansible



Resource – Communication

A channel with infinite bandwidth, zero power consumption, but a 1 minute latency.

The Goal Posts Have Moved



Special

You can change the current goal by changing either the *Task* or the *Environment* card.

"We must run as fast as we can, just to stay in place. And if you wish to go anywhere you must run twice as fast as that."

Theory of Everything



Special

A reviewer can use this card to dismiss the paper as over-reaching.

The results should be more concrete.

The Power of Friendship



Special

Use a card belonging to somebody else.

Competitive Collaboration



Special

You can use the cards of another player to create a design. However, if the paper is accepted, only one of you, decided randomly, will get the *Name Recognition* reward.

10× Multiplier

$\times 10$

Special

One resource can be multiplied by 10.

2× Multiplier

$\times 2$

Special

One resource can be multiplied by 2.

5× Multiplier

$\times 5$

Special

One resource can be multiplied by 5.

I Have an Idea!



Special

Create a new card using one of the empty cards. Put it randomly in the deck.

3D Printer



Special

Everything is now possible!

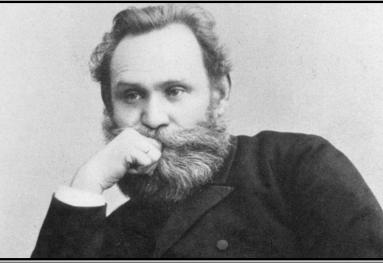
∞ Multiplier

∞

Special

One resource can be multiplied by ∞ .

A Russian Did It in the 1960s



Special

The paper under review is rejected.

Fundamental Theorem

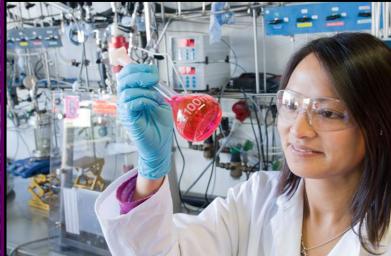


Special

This card can be played by a reviewer to reject a paper by appealing to authority.

The Fundamental Theorem of Robotics (Egerstedt, 2002) subsumes all subsequent results.

Very Dedicated Grad Student



Resource – Collaborator

Genius is one percent inspiration, ninety nine percent perspiration.

Steve LaValle



Resource – Collaborator

Thanks to an optimal design of the minimal filter and policy, you can *handwave away* all the concerns regarding the computation requirements of the proposed solution.

I was never a big fan of patents, but now I have a couple.

Friend on IRB Committee



Resource – Collaborator

The IRB will approve your project in spite of its questionable ethics. This card is especially useful in conjunction with *Very Dedicated Grad Student*.

Lazy Graduate Student



Resource – Collaborator

Procrastination is not the same thing as laziness. Laziness is when you don't want to do anything. Procrastination is when you don't want to do the one thing you really ought to be doing.

Play as a Goalie



Task

Play as a goalie in the World Cup.

Find All Easter Eggs



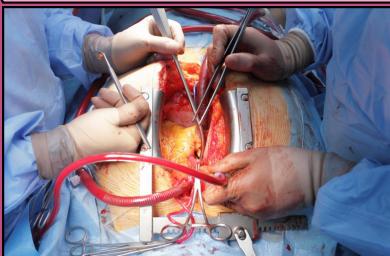
Task

Assemble IKEA Furniture



Task

Perform Surgery



Task

Sort Fruits by Color



Task

Rescue All Survivors



Task

Change a Diaper



Task

Play Chess



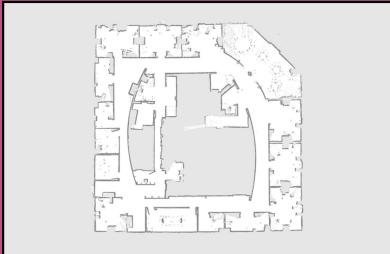
Task

Find and Disarm an IED



Task

Intel Lab, Seattle



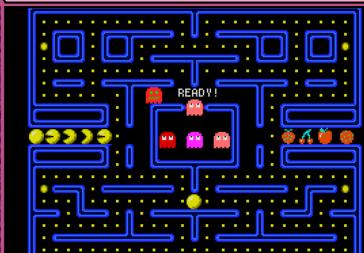
Environment

Under the Sea



Environment

Pacman's Maze



Environment

If Pac-Man had affected us as kids, we'd all be running around in dark rooms, munching pills and listening to repetitive electronic music.

Lake Michigan



Environment

Did you remember the O-rings?

Mount Etna, Sicily



Environment

Deep Space



Environment

Echo Base, Hoth



Environment

The Bates Motel



Environment

The Bat Cave



Environment

The Dagobah Swamps



Environment

Tatooine



Environment

Victoria Crater, Mars



Environment

Mars is the only planet completely inhabited by robots.

The Forest Moon of Endor



Environment

Ice Rink



Environment

Ski Slope



Environment



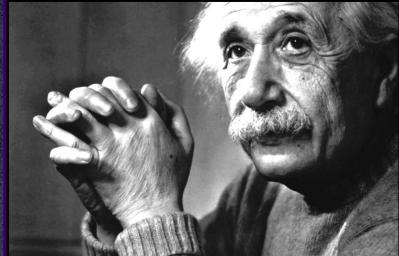
Name Recognition



Rewards

This card counts as one positive reviewer.

Name Recognition



Rewards

This card counts as one positive reviewer.

Bitterness



Rewards

Your negative opinion as a reviewer counts double.

Bitterness



Rewards

Your negative opinion as a reviewer counts double.

