## index

Numbers	Block Palette, MINDSTORMS App, 10, 11, 77	ceiling operator, 66
1L pin connector, 108	Boolean blocks	center button light, Hub, 19, 54
2L axle connector, 108	conditional blocks, 46-47	change block, for variables, 77-78
2L pin connector, 108	Control blocks, 43–48	chaotic car project, 49
3L pin connector (H pin), 102	operators, 66	checkerboard pattern, on Hub light matrix, 17
3L pin with center pin hole, 106	for remote control, 71	Cinderella, 112
3L pin with stop bush, 106–107	Sensor blocks, 53, 55, 58, 60-61	clown car project, 50
3×3 connector block (biscuit), 102	when condition true Event block, 41-42	coasting, 33, 35
·	braking motor, 33, 35	Code icon, MINDSTORMS App, 9
3×3 pin connector (L pin), 102	brightness, Hub light matrix, 17, 18	Coding Canvas, MINDSTORMS App
A	broadcast and wait block, 42–43	checking sensor values in, 93
	broadcast block, 42–43	creating first program in, 10
absolute position, motor, 31	building techniques	Hub icon and dashboard, 13–14
abs operator, 66	axles, 103–104	overview, 10-11
acceleration, 33-34, 35, 36	cables, thinking about, 105–106	storage position, download, and stream-
Accelerometer, 40, 51, 56, 58	connectors, knowing, 100–102	ing, 12–13
add item to list block, 80	fixes for fairy tales and fables, 111–118	word blocks, 11-12
Add sound option, play sound until done	multiple points of connection, using, 98-99	color detector project, 89
block, 20-21	nice part usage, 106–108	Color mode, Color Sensor, 53–54
and operator, 66, 67, 74	overview, 97	Color Sensor
angle beams, 99	planning ahead, importance of, 97–98	Boolean blocks, 41–42
animal, displaying on Hub light matrix, 24	projects, 109	Color mode, 53–54
animations, playing in Hub light matrix, 18	reinforcement, adding just enough, 105	Event blocks. 38–39
arithmetic operators, 65-66	right angles, using where possible, 99	in fan robot. 7
axle and double pin connectors, 101		
axle and pin connectors, 101	testing, 106	monitoring with remote control, 72, 73
axle joiners, 107–108	bushes/bushings, 97, 103, 104, 108	multiple points of connection for, 99
axle pins, 100	button presses, responding to, 40–42	overview, 53
axles	buttons, Hub, as sensors, 60–61, 62	Reflect mode, 13–14, 53, 54–55, 72, 79
building techniques, 97, 103-104	С	testing one thing at a time, 92
for motorized wheels in car robot, 3		using variables for sensor readings, 79
for nonmotorized wheels in car robot, 4	cables	comments, adding to programs, 91
spacers on, 108	in car robot, connecting, 4–5	Community icon, MINDSTORMS App, 15
	thinking about when building, 105-106	compact joins, 107
В	car robot	"Competition Ready" unit, 6
beams	attaching more wheels for balance, 3-4	conditional Control blocks, 46–48
adding studs to, 107	attaching two motors to Hub, 2	connection, using multiple points of, 98–99
connectors, 100–102	attaching wheels to motors, 3	connections, checking, 91
cross-bracing, 101, 103	chaotic car project, 49	connector pins/pegs, 2–3, 100
multiple points of connection for, 98–99	Color Sensor in Reflect mode on, 54–55	connectors, 97, 100–102
never using axles to replace, 103	connecting cables, 4–5	contains? block, 68
overview, 97	design flaws, spotting, 5	Control blocks
right angles, using when building, 99	driving on curve, 6	conditional blocks, 46-48
securing axles to, 103–104	flipped, 8	controlling single motor, 26
beats, play note block, 22	going further with, 6	loop blocks, 44
beeps, playing, 19–20, 43, 56	overview, 1	overview, 37, 43
Belling the Cat fable, 114	remote controlling, 71–72	projects, 49–51
block extensions, 11–12	running, 5–6	stop blocks, 45–46
DIOCH EXCENSIONS, 11-12	caster wheel, SPIKE Prime, 4	wait blocks, 43–44

Control widgets, 70, 71–72	timer, 40-41	Н
Cookie Clicker-style program, 77–78	when condition true, 41-42	half bushes, 108
copying code with Word Blocks, 12	when key pressed, 41	half pins, 106, 107
core set models, MINDSTORMS App, 15	when program starts, 37–38	hat blocks, 70, 71, 73. See also Control blocks
countdown projects, 88	extensions, block, 11-12	help, MINDSTORMS App, 15
count variable, 77-78	Extensions window, MINDSTORMS App,	holding position, stopping motor by, 33, 35
crank-slider mechanism, 8	11, 12	Home icon, MINDSTORMS App, 15
crawling robot, 8	external sensor Event blocks, 38-39	Hub
cross-axle connector pins, 100		built-in sensors, 39-40, 56, 58-60
cross-bracing, 101, 103	F	buttons as sensors, 60–61, 62
curve, driving car robot on, 6	fables, designing solutions for, 114-118	in car robot
curved beams, 8	fairy tales, designing solutions for, 111-113	attaching two motors to, 2
cycling through contents of list, 83	fan inventions, in MINDSTORMS App, 15	connecting cables to, 4–5
_	fan robots, 6–7, 74	design flaws, spotting, 5
D	fast mode, acceleration/deceleration, 33-34	overview, 1
deceleration, 33, 35	Fizz Buzz project, 88	running car robot with, 5–6
decomposition, 84	flashing lights, programming, 24	connecting to MINDSTORMS App, 9-10
defaults, overriding Movement block, 30-31	flexible axle connector, 107–108	controlling single-motor builds, 6–7
define block, 84	flipped car robot, 8	displaying value of Distance Sensor on, 55
delete all of list block, 80-81	floor operator, 66	internal sensor Event blocks, 39–40
deleting items from list, 81	Force Sensor, 39, 57, 63	light matrix, 17–19, 22, 24, 94
directions, motor, 25	forever loop	organizing programs in, 14
Distance Sensor	and Color Sensor, 55	planning build around, 98
controlling lights in, 19	controlling single motor, 26	playing beeps in, 19–20
Event blocks, 39	cycling through contents of list, 83	playing sound files in, 20–21
in fan robot, 7	and Distance Sensor, 56	storage position, download, and
overview, 55-56	if then block in, 46	streaming, 12–13
using stop blocks along with Event	overview, 44	timer, 40-41, 61
blocks, 45	sensing Hub buttons, 60-61	updating, 9-10
documentation, adding to programs, 91	and stop blocks, 45	Hub Dashboard, MINDSTORMS App, 13-14, 93
do not disturb project, 63	troubleshooting, 95, 96	Hub icon, MINDSTORMS App, 13
double angle beams, 99	four-wheeled vehicles, 3-4	
double pin with axle hole, 102	Fox and the Goat fable, 116-117	1
Download mode, MINDSTORMS App, 12-13	Fox and the Grapes fable, 115	if then block, 46
D-pad, remote control with, 71	Fox and the Pheasants fable, 114	if then else block, 47–48, 55, 58–59, 60–61
driving bases, 6. See also car robot	frames, 97, 99, 100-102	indexes, working with, 81–82, 83
duplicating code, with Word Blocks, 12	friction, pins with, 100	initializing variables, 79
duration, motor, 26, 29	frictionless pins, 100	inputs, adding to My Block, 86
		inserting items in list, 81–82
E	G	instrument, choosing for music, 23, 85
Edit sound option, play sound until done	gears, 7, 104	internal sensor Event blocks, 39–40
block, 21	gestures, Hub, 40, 56, 58	is button? block, 60-61, 62
equal to block, 65, 67	Goldilocks and the Three Bears, 111	is distance? block, 55, 56
Event blocks	grabber, motorized, 7	is in between? block, 67, 68
external sensor, 38–39	greater than block, 67	Isogawa, Yoshihito, 97
internal sensor, 39-40	Gyro Sensor	is pressed? block, 57
message blocks, 42-43	do not disturb project, 63	item # of thing in my list block, 82
overview, 37	Event blocks, 39-40	iterations, 44
programming with variables, 78	Hub pitch angle, 18	
projects, 49–51	overview, 56	J
sensing Hub buttons, 61	pitch, roll, and yaw, 59-60	join block, 68, 87
stop Control blocks, using with, 45	racket project, 51	J-= 2.55., 55, 57

K	М	projects, 36
keyboard, using as sensor, 61-62	main stack, 85	setting motor speed, 27–28
key pressed? block, 61-62	Make a Block window, MINDSTORMS App, 86	starting and stopping, 26–27
key presses, starting stack with, 41	Make a Variable option, MINDSTORMS App, 77	motor go to position block, 26, 31
	Mastering LEGO MINDSTORMS (Bratzel and	motor go to relative position block, 31
L	Torok), xvi	motorized grabber, 7
left, right, or both? project, 74	meshed gears, in motorized grabber, 7	motors. See also Motor blocks
LEGO Education SPIKE Prime set	message blocks, 42-43, 50	acceleration, setting, 33–34, 35, 36
caster wheel, 4	MIDI (Musical Instrument Digital Interface), 19	building techniques, 99
driving bases, 6	Milkmaid and Her Pail fable, 115	in car robot
Force Sensor, 39, 57, 63	MINDSTORMS Robot Inventor App. See also	attaching to Hub, 2
overview, xv	Word Blocks	attaching wheels to, 3–4
LEGO MINDSTORMS Robot Inventor set	accessing existing projects, 15	design flaws, spotting, 5
building techniques, 97-108	accessing help and settings, 15	chaotic car project, 49
external sensors, 38–39	Coding Canvas, 10–15	deceleration, 33, 35
fast fan, making from parts in, 6–7	core set models and fan inventions, 15	monitoring with remote control, 72, 73
overview, xv	first program, writing, 9-10	More Motors extension blocks, 31–34
LEGO units, 100	overview, 9	More Movement extension blocks, 34–35
length of block, 68	remote control, turning device into, 69-72	Movement blocks, 29–31
less than block, 67, 68	mod operator, 65	power, 32-33, 35
letter, programming robot to trace, 36	Monitor, MINDSTORMS App	push-button motor project, 62
letter of block, 68	checking sensor values in, 93-94	single-motor builds, 6-7, 25-26
Light blocks	Hub gestures in, 58	speed, 25, 27–28, 31, 32–33, 63
clown car project, 50	monitoring variables, 78-79	stall detection, 34
controlling Hub light matrix, 17–19	overview, 14-15	stopping, 33
controlling other lights, 19	updating lists from, 81	synchronizing, 28
overview, 17	viewing list contents with, 80	testing one thing at a time, 92
projects, 24	Monkey and the Cat fable, 117-118	two-way push-button motor project, 62
in troubleshooting, 92	More Motors extension blocks	viewing information in MINDSTORMS
Light icon, MINDSTORMS App, 10	absolute position vs. relative position,	App, 13
light matrix, Hub, 17-19, 22, 24, 94	31–32	move for duration block, 29
light value variable, 79	choosing ways to stop, 33	movement, detecting Hub, 40, 56, 59–60
list block, 80	controlling motors with speed, 31	Movement blocks
lists	overview, 31	controlling car with D-pad, 71
creating, 80	setting motor acceleration, 33-34	More Movement extension blocks, 34–35
cycling through contents of, 83	setting speed vs. power, 32–33	moving for a duration, 29–30
overview, 77, 79-80	stall detection, 34	overriding defaults, 30–31
projects, 88-89	More Movement extension blocks	overview, 25, 29
resetting, 80-81	moving with power, 35	projects, 36
updating from Monitor, 81	moving with speed, 35	starting and stopping movement, 30
using other list blocks, 82	overview, 34	move with steering for duration block, 29 multiple motors, controlling, 28–29
working with indexes, 81-82	setting brake/hold position/coast, 35	, J
literal strings, 68	setting movement acceleration, 35	multiple points of connection, using, 98–99
Little Red Riding Hood, 113	tank steering, 34–35	Music extension, 19, 22–23, 51, 84
logic operators, 66–68	Motor blocks	My Blocks
loop Control blocks	controlling multiple motors, 28	adding inputs to, 86
cycling through contents of list, 83	controlling single motor, 25-26	creating, 84–85
overview, 44, 49-50	More Motors extension blocks, 31–34	and ease of programming, 87
troubleshooting, 94–95	motor reporter blocks, 28-29	overview, 77, 83–84
	overview, 25	projects, 88

N	programs. See also troubleshooting	S
nested conditional blocks, 47-48	organizing in Hub, 14	sensors. See also Color Sensor; Gyro Sensor
nice part usage (NPU), 106-108	writing first in MINDSTORMS app, 9-10	Accelerometer, 40, 51, 56, 58
nonmotorized wheels, in car robot, 3–4, 5	Programs tab, Hub Dashboard, 14	checking values, when troubleshooting,
not operator, 67	Projects screen, MINDSTORMS App, 15	93-94
number input, adding to My Block, 86	proof of concept, 106	detecting Hub orientation and motion, 56,
	push-button motor project, 62	58–60
0		displaying information in Hub light matrix,
operators, 59	R	18
arithmetic, 65–66	race conditions, 38, 95-96	Distance Sensor, 7, 19, 39, 45, 55-56
Boolean blocks, 41, 42	racket project, 51	external sensor Event blocks, 38-39
logic, 66-68	random number, operator picking, 66	Force Sensor, 39, 57, 63
overview, 65	range, checking values within, 67	internal sensor Event blocks, 39-40
pick random number block, 66	Rapunzel, 111–112	keyboard, using as, 61-62
projects, 74	rattlesnake project, 49	monitoring with remote control, 72, 73
string, 68	Record sound option, play sound block, 21	overview, 53
orientation, Hub, 18-19, 39-40, 56, 58-59	Reflect mode, Color Sensor, 13–14, 53,	projects, 62-63
Orientation tab, Hub Dashboard, 14	54–55, 72, 79	sensing Hub buttons, 60-61
or operator, 66	reinforcement, adding just enough, 105	for single-motor builds, 6-7
overriding Movement block defaults, 30-31	relative position, motor, 31-32	timer, 61
	remote control, 14	using variables for readings, 79
P	checking sensor values in, 93	viewing information in MINDSTORMS App,
pan left/right blocks, 22	configuring, 69–70	13, 14
parameters, adding to My Block, 86	monitoring motors and sensors with,	Sensor widgets, 70, 72
patterns, in Hub light matrix, 17	72, 73	set 1 motor rotation to block, 31
pauses, adding to check program flow, 92	overview, 69	set block, for variables, 77-78
pick random number block, 66	programming, 70–72, 73	set instrument to block, 23
pins/pin connectors, 2-3, 97, 102, 108	projects, 75	set motor speed block, 27, 28
pin with pin hole, 106, 107	repeat block, 44, 83, 86	set movement motors to block, 30–31
pitch	repeat until block, 44	set movement speed block, 30
Hub, 59-60	replacing items in list, 81–82	Settings icon, MINDSTORMS App, 15
of sounds, adjusting, 22	reporter blocks	set variable block, 79
pitch angle block, 68	gesture, 58	Show Block Extensions icon, MINDSTORMS
pixels, in Hub light matrix, 17, 18	Motor blocks, 28–29	App, 11, 31
planning ahead, importance to building, 97-98	overview, 22	Show/Hide Card icon, MINDSTORMS App, 78
play animation block, 18	Sensor blocks, 53 for variables, 77, 78	single-motor builds
play animation until done block, 18	reset timer block, 40–41, 61	controlling single motor with Motor blocks,
play beep for seconds block, 19-20, 42	rests, programming in music, 23	25–26
play note block, 22	right angles, using when building, 99	fast fan, 6-7
Play program	Robot Inventor set	motorized grabber, 7
controlling single-motor builds, 6–7	building techniques, 97–108	sliders, remote control with, 71–72, 73
running car robot with, 5-6	external sensors, 38–39	sliding pieces, in car robot, 3
play sound block, 20-21, 38	fast fan, making from parts in, 6–7	Sound blocks
play sound until done block, 21	overview, xv	adjusting sounds, 21–22
points of connection, using multiple, 98-99	roll, Hub, 59–60	clown car project, 50  Music extension, 22–23
position, motor, 25, 26, 28-29	rotation, Hub, 59–60	overview, 19
power, motor, 32–33, 35	round operator, 65	
pressure, measuring with Force Sensor, 57	rubber tires, for nonmotorized wheels, 4	playing beeps, 19–20
problems, minimizing, 91	run motor for duration block, 26, 28	playing sound files, 20–21
programming with Word Blocks. See Word	running con nobet E (	projects, 24

running car robot, 5-6

Blocks

racket project, 51	timer, Hub, 40-41, 61	very slow mode, acceleration/deceleration,
in troubleshooting, 92	Tortoise and the Ducks fable, 117	33–34
and when program starts block, 37–38	tracing letter, programming robot for, 36	volume blocks, 22
sound files, playing, 20-21	Tricky robot, 6	144
spacers on axles, 108	troubleshooting	W
speed	avoiding problems, importance of, 91	wait for seconds block, 26, 27, 43-44, 92
motor, 25, 27-28, 31, 32-33, 63	checking connections, 91	wait until block, 43-44, 56, 66, 67, 78
movement, 30, 35	checking program flow, 92	walking robot, 8
SPIKE Prime set	checking sensor values, 93-94	waving hand project, 36
caster wheel, 4	looking at loops, 94-95	weight distribution of robots, 5, 98
driving bases, 6	overview, 91	wheels
Force Sensor, 39, 57, 63	race conditions, 95-96	in car robot, 2–4, 5
overview, xv	testing one thing at a time, 92	SPIKE Prime caster, 4
spinning car robot in place, 6	turning robot 90 degrees, 30	when button pressed Event block, 40, 41, 78
stacks of blocks, 11, 37, 85. See also Control	turn on for 2 seconds block, 10	when color is Event block, 38–39
blocks; Event blocks	"Twinkle, Twinkle Little Star," coding, 85	when condition true Event block, 41–42, 67
stall detection, 34	Two Goats fable, 116	when I receive message block, 42
start motor block, 26, 27	two-motor builds	when key pressed Event block, 41
start moving block, 30	car robot, 1-6	when program starts block, 10, 37–38, 84
steering, 29, 34-35	chaotic car project, 49	when timer block, 40-41
stop all sounds block, 20, 21	flipped car robot, 8	widgets, for remote control, 69–72
stop Control blocks, 45–46	More Movement extension blocks, 34-35	wire clips, 105-106
stop motor block, 26	Movement blocks, 29-31	Word Blocks. See also sensors
stop moving block, 30	moving without wheels, 8	block extensions, 11-12
stop other stacks block, 45, 46, 96	remote controlling, 71–72	Control blocks, 37, 43-48
stopping motor, 26–27, 33	testing one thing at a time, 92	creating first program with, 10
stops, axles with, 103-104	two-way push-button motor project, 62	duplicating code, 12
storage position selector, MINDSTORMS	two-wheeled robots, moving for duration, 30.	Event blocks, 37-43
App, 12-13	See also car robot	fixes for fairy tales and fables, 111-118
Streaming mode, MINDSTORMS App, 12-13		Light blocks, 17–19
string operators, 68	U	lists, 79–83
studs, adding to beams, 107	unregulated mode, motors, 32	More Motors extension blocks, 31-34
synchronized motors, 28, 29, 34–35		More Movement extension blocks, 34-35
	USB cable, connecting Hub via, 9	Motor blocks, 25–29
Т	V	Movement blocks, 25, 29-31
	•	My Blocks, 83-87
table drop project, 109	variables, 15, 68	operators, 65-68
tank steering, 34–35, 71	creating, 77–78	overview, 10, 11
tempo, setting, 22, 85	initializing, 79	remote control, 69–72
testing	lists, 79-83	Sound blocks, 19-24
one thing at a time, 92	monitoring, 78–79	troubleshooting, 91–96
when building, 106	overview, 77	variables, 77–79
text, showing in Hub light matrix, 18	programming with, 78	write block, 18, 38, 87
Three Little Pigs, 113	projects, 88-89	v
three-wheeled cars, 3	using for sensor readings, 79	Y
tilt-checking programs, 67-68	vehicle robot. See car robot	yaw, Hub, 59–60