

KIT 12 - INVENTOR'S LAB





## DEAR LEGO® MASTER BUILDER ACADEMY MEMBER,

I am very proud of being part of the team behind LEGO® Master Builder Academy. I have been working as a LEGO Designer for more than 30 years, and even after so much time, I'm still learning new ways of using LEGO bricks and finding inspiration in what new designers are building.

I have created a lot of different LEGO sets through the years, but my favorites have always been models that have movement and functionality. It's one thing to build a cool-looking car, helicopter, carousel, or whatever else you can imagine, but quite another to include real functions in your model. That's where you really get challenged as a designer!

In this kit, we will show you how to build some amazing inventions and mechanisms. When it comes to building functions into models, it is important to know how the functions work in real life. You can find information in books, movies, and online, or do as the LEGO Technic designers do and look at full-sized cars, trucks, and cranes.

Before finishing your model, always remember to test your function. Can it keep moving without falling apart? How heavy a load can it lift without breaking? Good luck designing, and who knows – maybe you will invent something that's never been seen before!

**KEEP YOUR EYES OPEN!**

*Steen Sig Andersen*

Steen Sig Andersen,  
LEGO Designer





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# YOU ARE THE INVENTOR

## BUILD YOUR OWN WORKING FUNCTIONS!

Are you ready for the ultimate design challenge? All of your LEGO® Master Builder Academy Level 4 training has led up to this: *THE INVENTOR'S LAB!*

Here in Kit 12, you'll follow in the footsteps of one of history's most celebrated inventors. Leonardo da Vinci spent his life observing, thinking, imagining and creating. Just like a LEGO Master Builder, he never gave up looking for new and interesting ways to do things, from practical tasks like keeping track of the time to seemingly impossible dreams like flying through the air.

Many of Leonardo's inventions were never built during his lifetime. But you have one advantage that even the great inventor lacked – a set of useful LEGO® Technic elements that you can assemble, take apart, and reassemble to make thousands of different moving, working functions.

As you progress through this handbook, you'll discover the linked LEGO Master Builder techniques of *INVENTIONS* and *FUNCTIONS*.



the two keys to designing working inventions. You'll build ten all-new springboard models, each with a unique mechanical function that you can incorporate into your own creations. And you'll assemble this kit's star model: *LEONARDO'S BOAT*, a realistic gear-driven vessel based on the sketches of Leonardo da Vinci himself.

Inventing is all about trial and error. You won't always make your creations work on the first try, but with patience,



experimentation, and the tips and techniques of the LEGO Master Builders, you'll find that your inventions will become more and more complex and advanced as you practice building them.

Now put on your Invent-o-Pack once more and get your Technic pieces ready. In this lab, you are the inventor... and the future is yours to build!





# CONTINUE THE ADVENTURE ON **LEGOmba.com!**

Your Invention Designer journey continues on the LEGO® MBA website!

The LEGO Master Builder Academy is much more than just the kits and designer handbooks. Check out [LEGOmba.com](http://LEGOmba.com) for the full online experience, including all-new videos, quizzes, skill tests, springboard model building instructions, and bonus tips from the real LEGO Master Builders. Earn badges, get feedback on your creations, and share your building knowledge with your fellow LEGO MBA members!



To join the online journey, visit [LEGOmba.com](http://LEGOmba.com) and use the exclusive code below to register your LEGO Master Builder Academy Level 4 membership. Once you've created or updated your account, click on Member Access and select Kit 12 from the book-box at the top right of your LEGO MBA design desk for full access to all Kit 12 articles and activities!

## **42KT-74XA**

THIS CODE UNLOCKS LEGO®  
MBA KITS 10, 11 AND 12

# INVENTIONS THAT CHANGED THE WORLD

*THE TIME MACHINE RATTLED AND SHOOK. HIS SITUATION WAS BECOMING DESPERATE.*

He had learned a lot from the skilled architects of the past, but it hadn't been enough to fully repair his most strange and astounding creation. The time machine was continuing to shed pieces as it hurtled through the time-stream, and sooner or later it was bound to lose something important.

As windows opened and closed in the storm, he caught glimpses of some of history's greatest inventions. Here, he saw a cart roll along a dirt road, its wooden wheels helping a farmer transport his crops to market. There, he saw a tall-masted sailing ship. Through one window he spied a light bulb, and in another an early automobile. Quickly rebuilding his Invent-o-Pack into a camera, he took photos of each one that he could. They filled his head with ideas for new creations...but if he couldn't get the time machine working, he might never have a chance to build any of them!

With a stutter, the time machine's spinning rotors started to slow. He knew what that meant: the steam boilers behind him had finally stopped. Now moving by momentum alone, the machine sailed through the time-stream, completely out of his control.

Would he be forever stranded here, trapped between moments in the swirling storm of history? Perhaps not, for the time machine's path seemed to be taking it on a course toward a solitary dark window. What could lie on the other side?





# THE INVENTOR'S LAB

HE BLINKED IN THE SUDDEN DARKNESS. WHERE WAS HE NOW? THE TIME MACHINE HAD ARRIVED SO SILENTLY THAT HE WAS HARDLY SURE IT HAD LANDED AT ALL. ONLY THE LACK OF CHRONAL WINDS BLOWING IN HIS FACE TOLD HIM THAT HE HAD ARRIVED AT HIS DESTINATION, WHATEVER IT MIGHT BE. IF ONLY HE HAD A LIGHT WITH WHICH TO SEE...

He smiled. Of course he had a light! Raising the camera, he took a snapshot.

**FWASH!** In the brief brightness of the camera's flash, he saw shapes all around him, strange objects that were both completely unknown and eerily familiar, as if remembered from a half-forgotten dream. He saw gears, levers, wooden frames, cloth and rope, all combined to form ingenious mechanisms and devices. He saw easels full of paintings and half-finished sketches. And he saw notebooks scattered about everywhere, open to pages filled with detailed illustrations and peculiar backwards writing.

Some of the machines were clearly revolutionary for their time, while others might never properly work, but still revealed the seeds of incredible new ideas and design techniques. He had never before seen so many brilliant creations in one place.

He saw all of this for only a moment, but it was enough. Now he knew where he was. It might be the one place that could help him get back home: the workshop of one of history's greatest inventors.



HE WAS STANDING IN THE  
LABORATORY OF LEONARDO  
DA VINCI.

THE LEGO® MBR MINIFIGURE'S ADVENTURE  
CONTINUES ON LEGOmba.com!

LEONARDO DA VINCI (1452-1519) was a Renaissance painter, architect, musician, mathematician, botanist, astronomer, engineer, and more. In his studies of both art and science, he filled his journals with sketches and notes (often written backwards in mirror script) for hundreds of new inventions.

Many of Leonardo's ideas were turned into real, functional machines, like his lens-grinder that used a rotating handle and gears to grind glass into magnifying lenses. Others were too expensive or difficult to construct with the technology and materials of the time, such as plans for new kinds of bridges and hydraulic water machines, and remained only drawings in his notebooks. But even when an invention couldn't be built or didn't work quite right, he learned from each one and worked to improve his designs for the next time.

Few of Leonardo's inventions capture the imagination like his concepts for flying machines, including an early version of a helicopter and a pyramid-shaped parachute for safely descending from great heights. Perhaps most well-known was a machine designed to fly by flapping its wings like a bird. These ideas displayed great engineering insight and a vivid imagination, and show how one creative person could combine his many talents to come up with inventions that, at the time, looked as much like science fiction as a time machine.

Leonardo da Vinci is considered to be one of the most prominent and influential inventors of all time. His inventions may not all have become reality, but they led to even more experimentation and advancement, and paved the way for thousands of useful machines that are still used around the world today.

EVERY GREAT INVENTOR STARTED  
SOMEWHERE - AND NOW IT'S YOUR TURN!





LEGO® MBA Technique:

# INVENTIONS

## TRANSFORM YOUR IMAGINATION INTO A NEW IDEA!

What totally new, awesome, and original thing can you think of for a LEGO® model to do? Don't worry about how you'll make it work yet – you'll handle that in this kit's second technique. For right now, just close your eyes and imagine a possibility. Got it in your head? Then you've just used the **INVENTIONS** technique!

### THINK UP SOMETHING NEW

Use the Inventions technique before you start to design or build a model. This technique doesn't use any bricks... at least, not yet. It's all about picturing a goal in your mind and challenging yourself to turn it into reality.

Where do new inventions come from? Most of them start with a need. Sometimes it's the need of a whole population, such as a way to cross a body of water or safely travel long distances.

Sometimes it's the need of the inventor to create something useful, or clever, or just plain cool.

STEAM-POWERED  
FIRE ENGINETWO-PISTON  
BOAT ENGINE

WHEN CREATING AN INVENTION MODEL, YOUR FIRST STEP SHOULD BE THE SAME AS ANY GREAT INVENTOR'S: COME UP WITH A BRAND-NEW IDEA!



SKIAMETER



## VISUALIZE YOUR IDEA

Once you have an idea, make sure to record it so that you don't forget it. Write it down, or even better, draw it! A picture will really come in handy when you start using the **FUNCTIONS** technique later on.



The world is filled with amazing inventions. There are probably dozens that you can see right now while you're reading this handbook, like electric lights, telephones, cameras, and computers. Each one was once the stuff of pure imagination until somebody thought it up, wrote it down, and made it work.

WHAT'S YOUR BIG IDEA?

LEGO® MBA Technique:

# FUNCTIONS

BRING INVENTIONS TO LIFE  
WITH YOUR LEGO® BRICKS!

Once you've used the Inventions technique to come up with a great idea for a moving model feature, the next step is to turn your imagination into reality by planning out, designing, and building a working version of your idea using the pieces in your LEGO® element collection. It's time to make some functions!

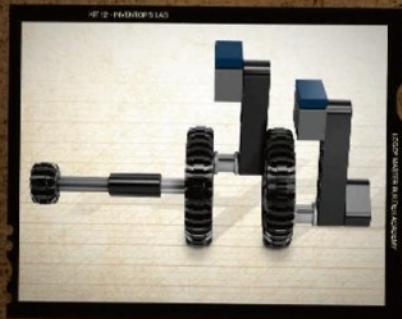
The **FUNCTIONS** technique involves the steps, parts, and details that make your invention move and act the way you want it to. When designing an invention model, you'll usually want to use LEGO® Technic elements to create moving functions. You first did this with the **LEGO TECHNIC ELEMENTS** technique back in Kit 6 – but where the functions you built then were simple and straightforward, the ones that you'll be creating in this kit are much more advanced.

With functions, you can make parts of your model change position, direction, and shape. They can go up and down, left and right, or round and round... and round...and round!

TAKE A LOOK AT SOME OF THE FUNCTIONS THAT THE LEGO® MASTER BUILDERS BUILT INTO THE KIT 12 LEGO MODELS THEY DESIGNED!



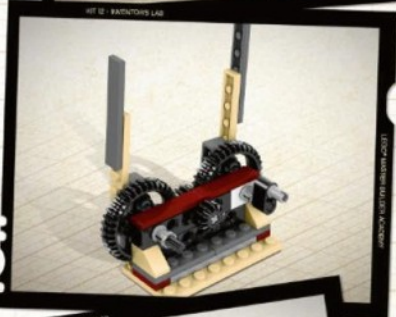
TURNING THE CRANK MAKES ONE LARGE GEAR SPIN QUICKLY AND THE OTHER SLOWLY!



ENGINE PISTONS ALTERNATE MOVING UP AND DOWN LIKE IN A REAL AUTO!



ATTACHMENTS OF DIFFERENT SIZES AND SHAPES CREATE DIFFERENT MOVEMENT EFFECTS ON EACH SIDE!



## DESIGNING A FUNCTION

Designing a new model function isn't always easy, but it can be a lot of fun. The best way that you can prepare is to practice building with the pieces that are used to make functions – especially Technic beams, gears, and connectors. Fortunately, you'll be getting plenty of experience with them right here in this kit!

When you start to understand how the different elements work and interact with each other, try making your own combinations of pieces. Start with easy functions and work your way up to more complicated ones. Don't worry if your function doesn't work exactly right the first time. Just take it apart and try again until you get it right!



NOW THAT YOU KNOW ABOUT FUNCTION-BUILDING ELEMENTS AND HOW THEY WORK TOGETHER, TAKE A LOOK AT YOUR NEW IDEA AND START FIGURING OUT HOW TO TRANSFORM IT INTO A REAL WORKING INVENTION!

# Camera BUILD

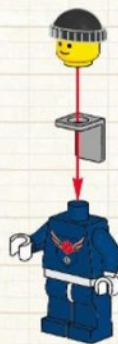
## GEAR FOR RECORDING IDEAS!

During his journey through the time-stream, the Level 4 LEGO® MBA Minifigure has seen many amazing and marvelous things. Each one has given him ideas for new inventions – but how can he keep track of them all?

The answer lies in his latest Invent-o-Pack creation: an idea-documenting camera! With its help, he'll be able to record everything he sees that inspires him to invent, and look at it again later when he's ready to start building. It can even attach to his back for storage when he's out exploring!




1






2


1




4




2




1




2

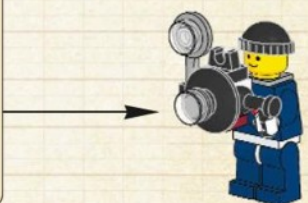


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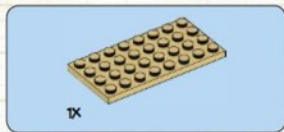


# LEONARDO'S BOAT

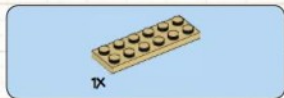
One of Leonardo da Vinci's most famous inventions is his hand-drawn design for a boat with two large paddle-wheels on its sides. A combination of gears causes the wheels to turn, propelling the boat quickly through the water.

The LEGO® Master Builders have used the Inventions and Functions techniques to transform Leonardo's illustration into a three-dimensional model. As you build Leonardo's Boat, look at the way that the gears work together to change the size and direction of the crank's movement, and imagine some of the inventions that you can create using the same pieces!

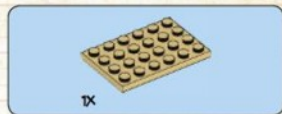
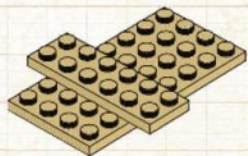




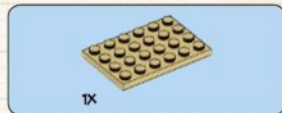
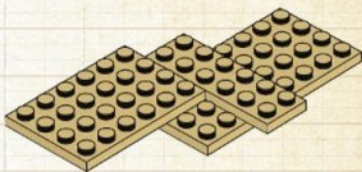
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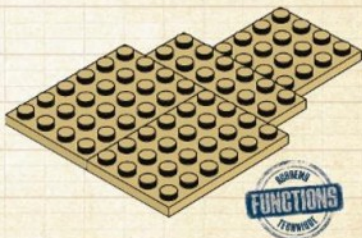
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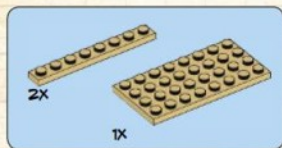


HERE'S THE LEGO® MASTER BUILDER  
TECHNIQUE OF INVENTIONS!

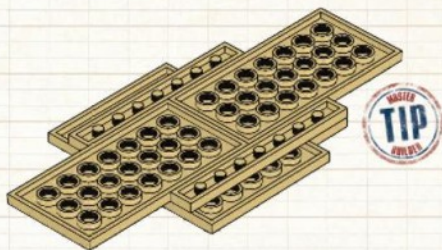
Every great invention starts with an idea. Leonardo's was to create a faster and more efficient way to row a boat. He wasn't the very first person to come up with this method, but the way that he did it was unique...and recreating it starts with this plate!

HERE'S THE LEGO MASTER BUILDER  
TECHNIQUE OF FUNCTIONS!

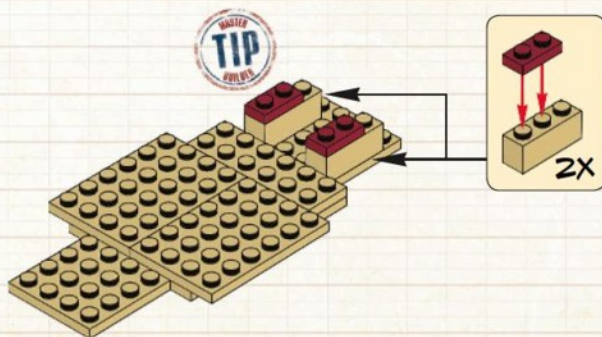
Functions are the technical part of your model, the elements that add mechanical realism. Your boat needs a lot of space for the gears that will turn its paddle-wheels, so prepare a nice wide platform for function-building.



5



6



#### STEP 5 TIP: STABLE FUNCTIONS

A working function needs to keep its parts perfectly lined-up, with no wobbling or falling apart. These **LARGE ELEMENTS** will **LOCK** the boat's underside together for an invention with maximum **STABILITY**.

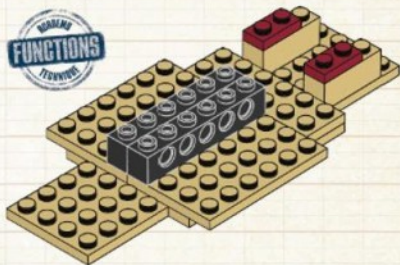
#### STEP 6 TIP: THINK ABOUT USE

Rather than building an invention that's all function and no fun, consider what features would make it better or easier to use. These bricks will be **SUPPORT ELEMENTS** for something useful at the back of your boat!

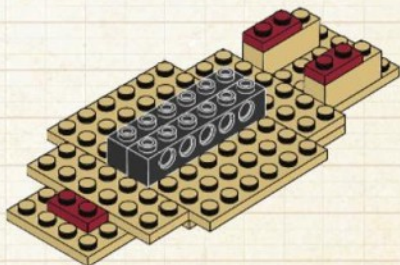




7



8



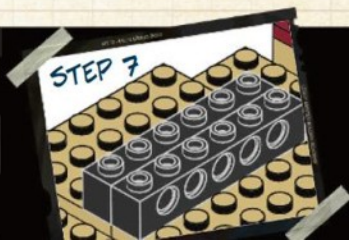
## PADDLE BOATS

Paddle-driven boats can be found in many different shapes and sizes, from small human-powered watercraft like Leonardo's invention to big passenger riverboats powered by steam engines.



### STEP 7 TECHNIQUE: FUNCTIONS!

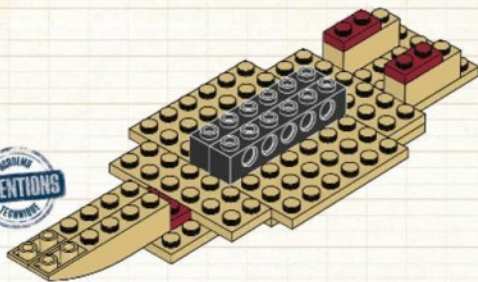
These two LEGO® Technic bricks with holes are perfect **SUPPORT ELEMENTS** for your model's main mechanism. They'll make a solid but lightweight base for moving parts, while providing clearance at the sides for the large rotating gears that will attach to the paddle-wheels.





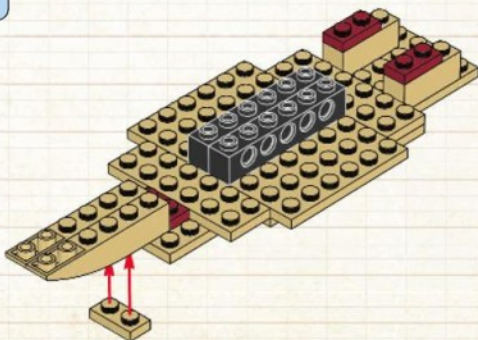
2x

9



1x

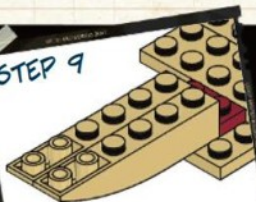
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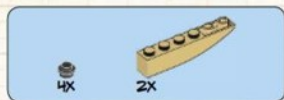


#### STEP 9 TECHNIQUE: INVENTIONS!

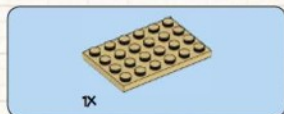
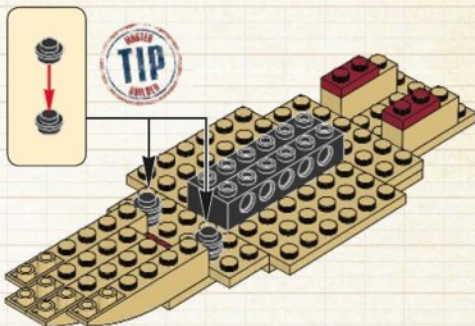
The boat is a very old invention, with a **SHAPE** that has been perfected over centuries of ideas and improvements. By making the front end curved and pointy, you'll help it slice through the waves without being slowed down by water resistance.

STEP 9

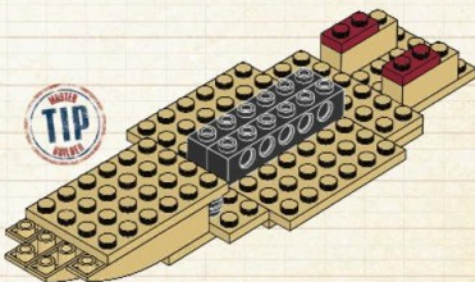




11



12



#### STEP 11 TIP: FILL THE SPACE

Remember your brick math! A 1x1 brick is too tall for these spots, and a 1x1 plate is too short. But stacks of two 1x1 plates – whether square or round – are just the right height to be internal **SUPPORT ELEMENTS**.

#### STEP 12 TIP: THE FIRST RULE

It's as true today as when you first practiced it in Kit 1: **LOCKING** is the most important technique you can use for building a strong and sturdy model!



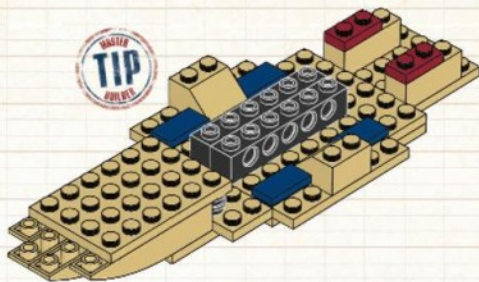


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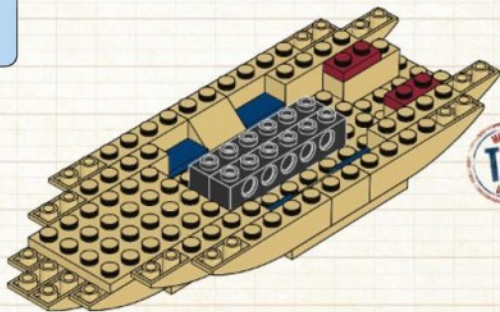
4x

13



8x

14

**STEP 13 TIP: SLOPED SIDES**

You could have built the sides of the boat's hull entirely out of 1-stud-wide bricks, but by using 2x2 sloped bricks as **SUPPORT ELEMENTS** for the powerful paddle-wheel mechanism that will go on top of them, you create a wider base for **STABILITY**.

**STEP 14 TIP: FORE AND AFT**

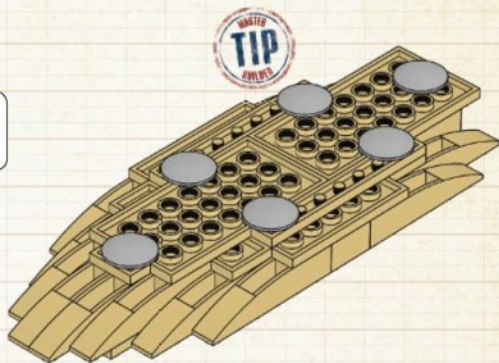
Continue to refine the **SHAPE** of the boat's hull with these inverted curved bricks. Adding smooth **STYLING** to the underside of models is what they were designed to do!





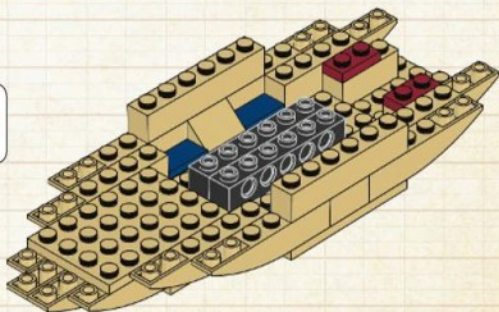
6X

15



2X

16



#### STEP 15 TIP: READY TO GLIDE

You can create a special movement effect by attaching round sliding plates to the bottom of your boat. They'll cut down on friction, letting your model glide across smooth surfaces as if it were floating on water.



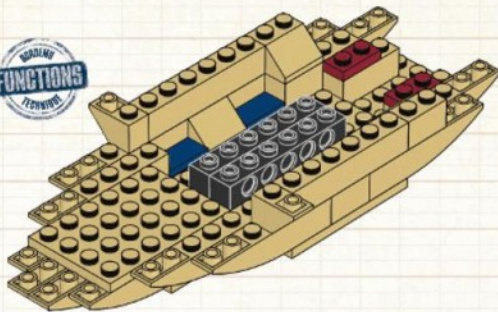


2X



2X

17



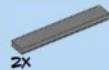
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2X

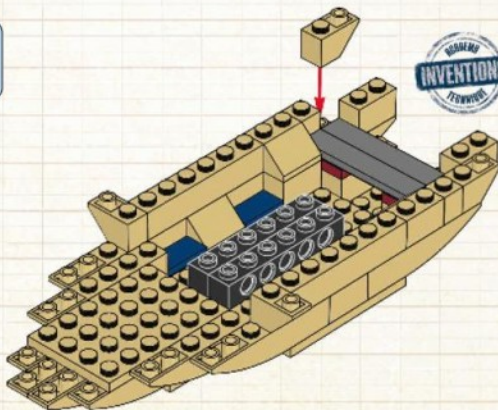


2X



2X

18

**STEP 17 TECHNIQUE: FUNCTIONS!**

Even though you haven't started assembling your invention's main mechanism yet, you can lay the groundwork by using lots of **SUPPORT ELEMENTS** – like these inverted 1x2 slope bricks – to hold up its many moving parts.

**STEP 18 TECHNIQUE: INVENTIONS!**

Even the simplest of ideas can be inventions as long as they're new. Since the first boats didn't have seats, people had to sit on the bottom...that is, until somebody invented a boat that was flat and wide enough to include a bench like this one.





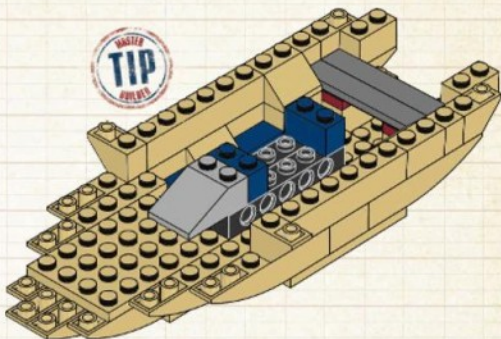


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19

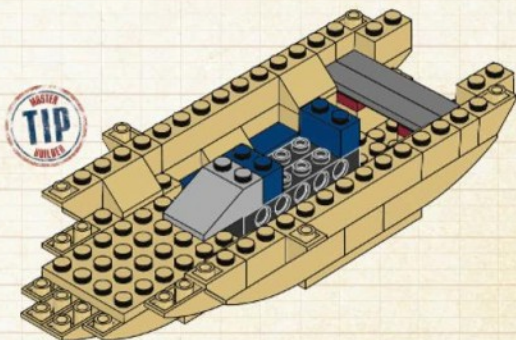


2x



2x

20

**STEP 19 TIP: KEEP ON LOCKING...**

There is a large and potentially model-weakening gap between your boat's mid-section and its raised front end. Fortunately, you can **LOCK** them to each other (and lock the two Technic bricks together at the same time) with one well-placed long slope brick.

**STEP 20 TIP: ...AND SUPPORTING**

Add two more 2x2 slope bricks to shore up the walls. They're in just the right place for gears to fit behind them.



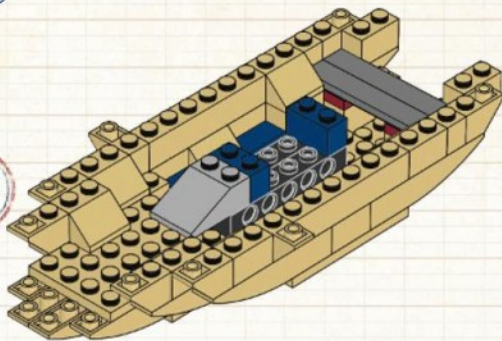


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2x

21

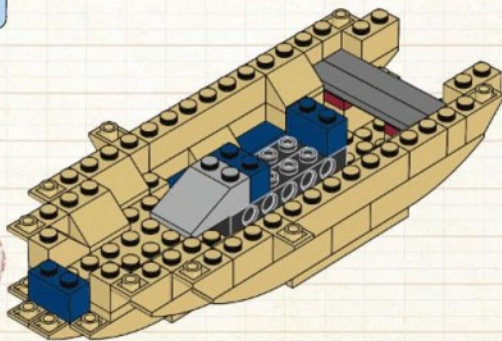


2x



2x

22

**STEP 21 TIP: USE NATURAL COLORS**

When Leonardo da Vinci designed his invention, there was no such thing as a steel boat. Smooth, curved, tan LEGO® elements look like smooth, curved, tan planks of wood – just like the MATERIALS of Leonardo's time!

**STEP 22 TIP: IGNORE HIDDEN COLORS**

The dark blue bricks that you've added in a few places don't match the bare-wood color of the boat's hull. Fortunately, as SUPPORT ELEMENTS, they'll be largely out of view when your model is complete.



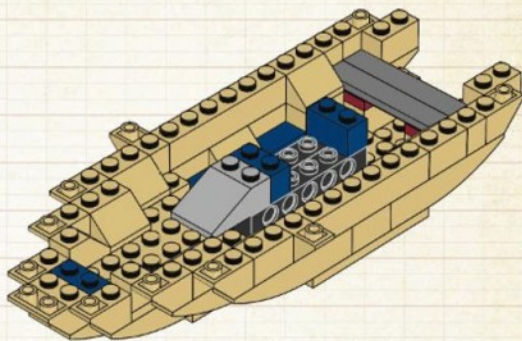


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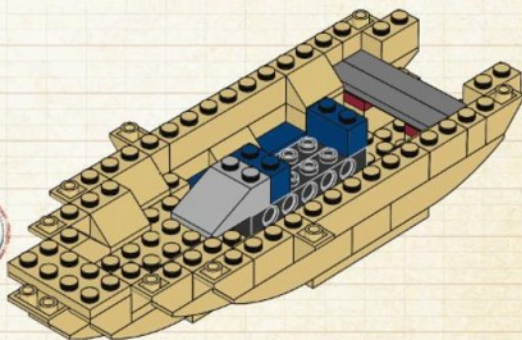
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23



1x

24



#### STEP 24 TIP: CREATE A SOLID SHAPE

Thanks to all of the inverted slopes and curves that you've used, you're nearly done with giving the boat's hull a realistic **SHAPE**. Inverted elements are less stable than other bricks because they're bigger at the top than at the bottom, so always make sure to **LOCK** them securely in place.



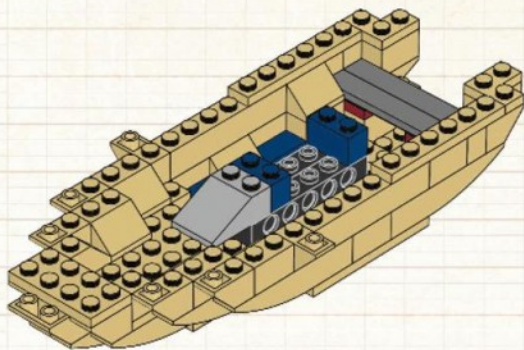


2x



2x

25

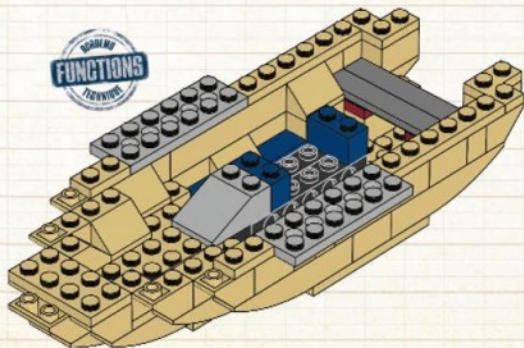


2x



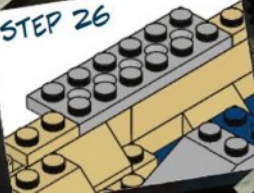
2x

26

**STEP 26 TECHNIQUE: FUNCTIONS!**

The inverted slopes that you added earlier act as supports for these two 2x6 plates with holes, increasing the width of your model. This allows the paddle-wheels to stick out further to the sides, improving the boat's **BALANCE!**

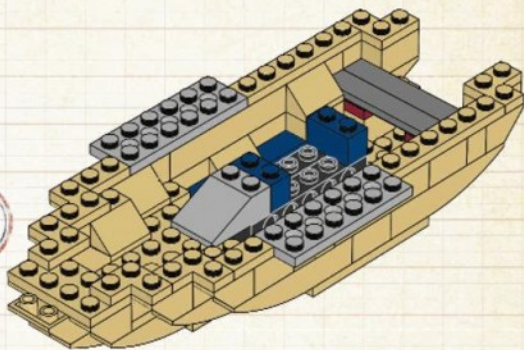
STEP 26





4X

27

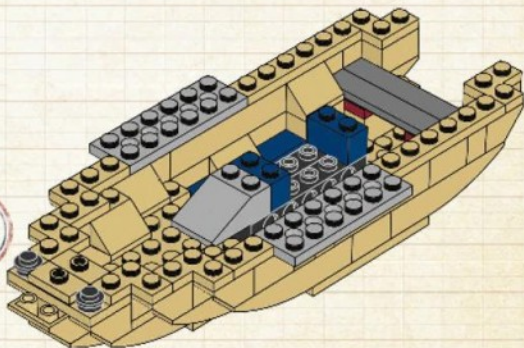


2X



2X

28



#### STEP 27 TIP: THE RIGHT PLATE FOR THE JOB

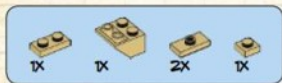
Designing a model with a curved or stepped outline? These L-shaped corner plates are great pieces for **LOCKING** unusual shapes together.



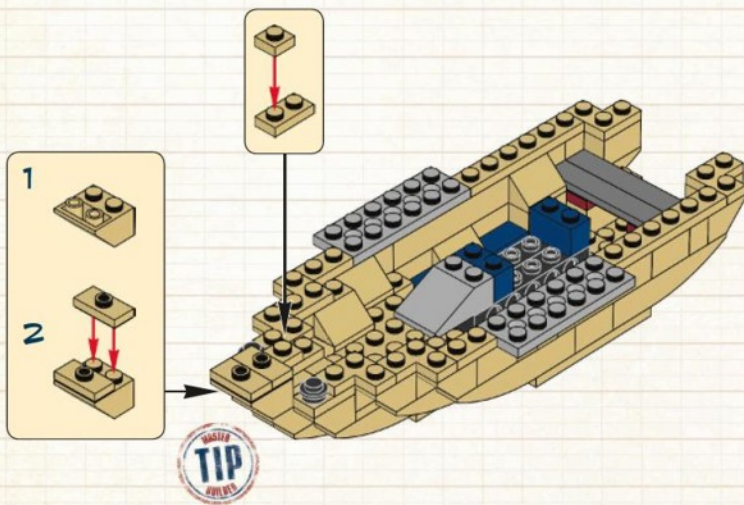
#### STEP 28 TIP: DECORATIVE DETAILS

While not necessary for the function to work, these round plates add a nice bit of **DETAIL** to your model to give it some extra visual interest.





29



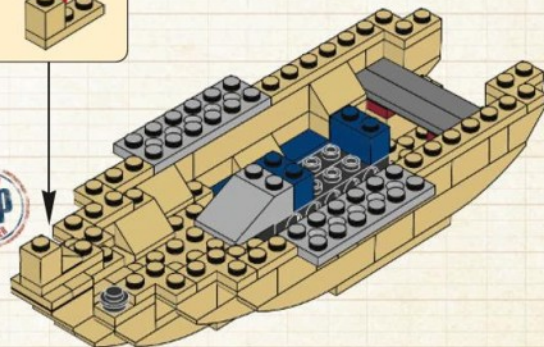
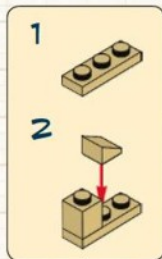
#### STEP 29 TIP: FRONT AND CENTER

How do you transform a two-stud-wide front end into a realistically peaked bow for your boat? First, place a pair of single-stud jumper plates on an inverted-slope brick to create a centered building platform.





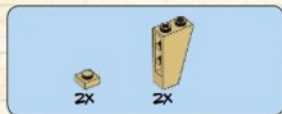
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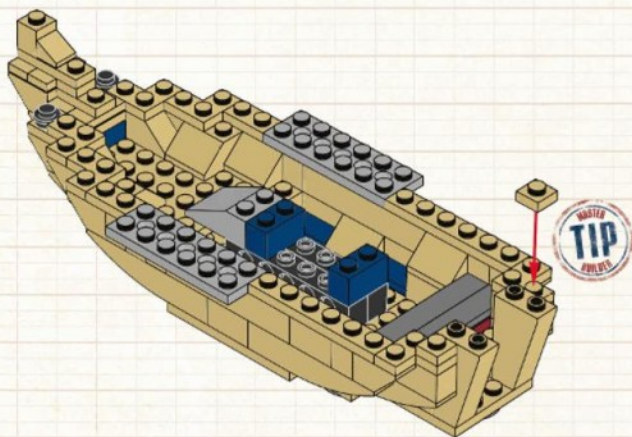
**STEP 30 TIP: SMALL PIECES, BIG IMPACT**

Now combine three **SMALL ELEMENTS** to give your boat a narrow one-stud-wide pointed bow right in the middle!





31

**STEP 31 TIP: ANGLED END**

Complete the boat-shaped **STYLING** of your model with two tall inverted-slope bricks in back. Two 1x1 **SMALL ELEMENTS** bring the sections alongside them up to the right level for locking.





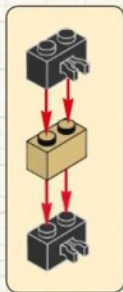
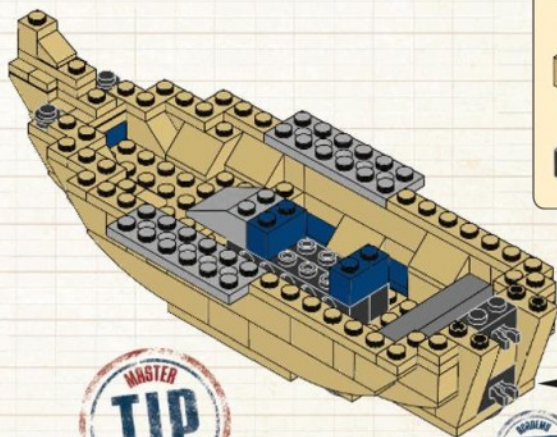


1X



2X

32

**BONUS TIP:**

MOVING AGAINST THE CURRENT CAN PUT A LOT OF STRESS ON A BOAT'S RUDDER. MAKE A STRONG HINGE BY USING BLACK BRICKS TO SIMULATE METAL MATERIALS!

**RUDDERS**

The rudder is a simple but practical invention that has been used in various forms for thousands of years. It is usually a flat vertical panel at the back of a vehicle that can be turned from side to side, redirecting the flow of water or air to change the vehicle's direction of movement. Look for rudders on the backs of boats and airplane tail-fins!

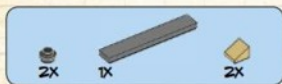
**STEP 32 TECHNIQUE: INVENTIONS!**

The paddle-wheels will give your boat propulsion, but how can you steer it? Here's an inventive idea: add a moving rudder! Two bricks with clips will let you create a clip-hinge. Spacing them out above and below a standard 1x2 brick will give you a stronger and more stable connection than you'd get by stacking them directly together, since the longer distance will make it tougher for the rudder to pop loose.

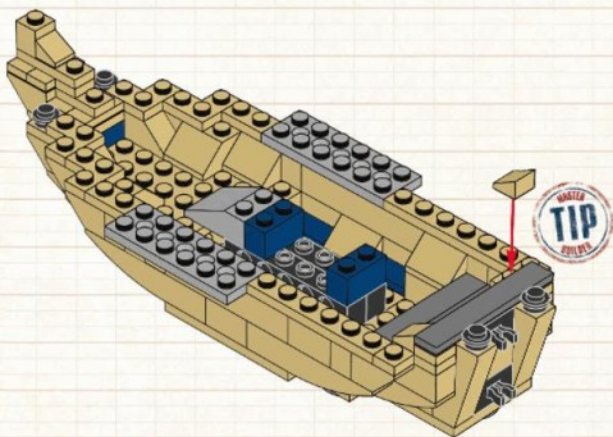


STEP 32

33

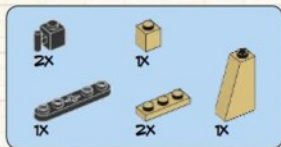


33

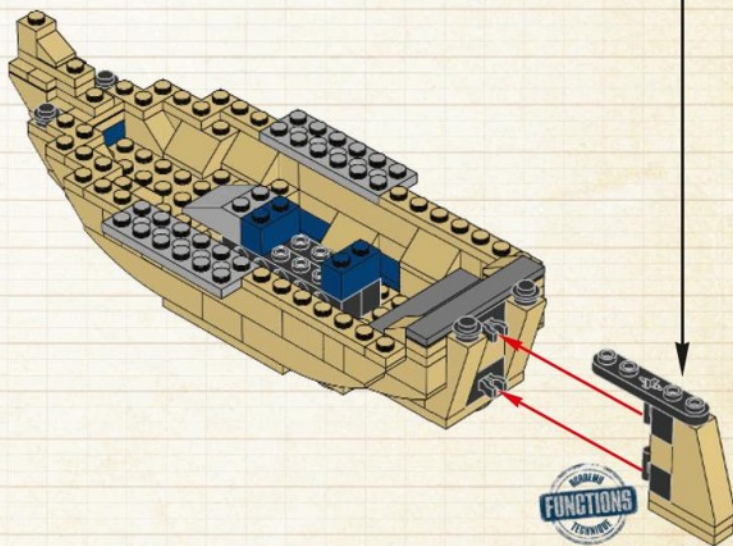
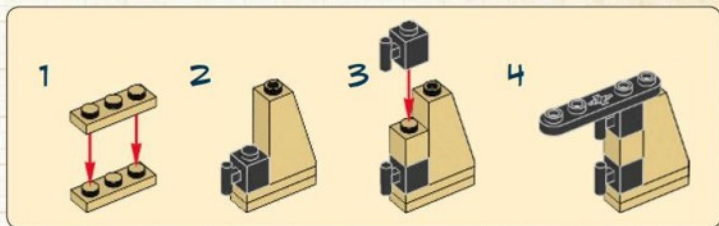
**STEP 33 TIP: SMOOTH MOVEMENT**

**LOCK** the back of the boat together with a tile. You'll need its stud-less top surface to let your rudder move. Include a few decorative **SMALL ELEMENTS** to continue the boat's **STYLING**, too!





34



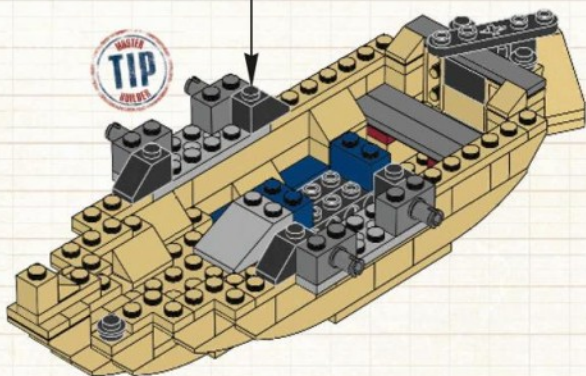
**STEP 34 TECHNIQUE: FUNCTIONS!**

Since you've already installed the clips, it's easy to attach a hinged rudder. A 1x4 **TECHNIC ELEMENT** makes a handy tiller-bar that someone sitting on the bench can swing back and forth to steer the boat. This is a basic function compared to the one you'll soon be building, but it's a function nonetheless!





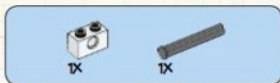
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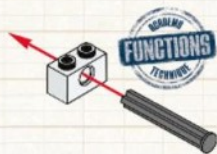
#### STEP 35 TIP: SIDEWAYS CONNECTIONS

By using bricks with connector pins, you make adding parts with *SIDEWAYS BUILDING* simple. Now any LEGO® element with a Technic hole in it can be attached to the side of your model.

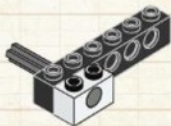




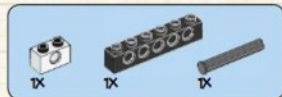
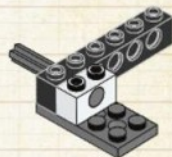
### 36.1



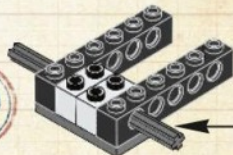
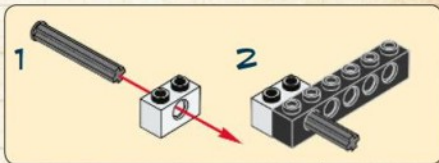
### 36.2



### 36.3



### 36.4



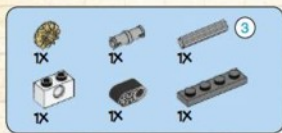
#### STEP 36.1 TECHNIQUE: FUNCTIONS!

Now that the body of your boat is complete, it's time to bring it to life with an advanced moving function. The coolest functions are built with **TECHNIC ELEMENTS**, so start by pushing a Technic cross-axle with a flat head through a brick with a Technic hole. In addition to creating a rotating axle, the brick will let you combine Technic parts with standard LEGO bricks, since it attaches to both.

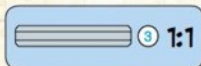
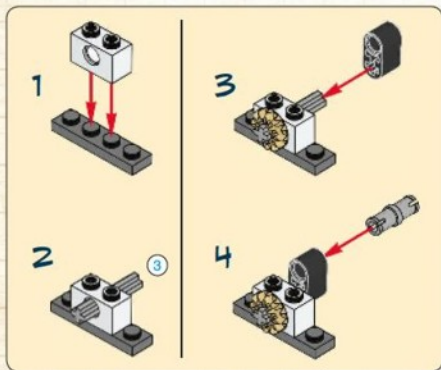
#### STEP 36.4 TIP: A DIFFERENT WAY TO LOCK

Thanks to the round indentation around the hole in the white bricks, the axle's head is flush with its surface instead of sticking out. This means that you can place two of them head-to-head and let them **LOCK** each other in place!



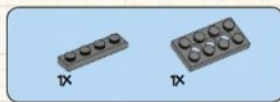


36.5

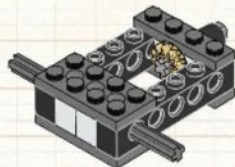


STEP 36.5 TECHNIQUE: FUNCTIONS!

Leonardo's original boat was designed to be driven by foot-pedals, but yours will have a hand-crank. Use a short Technic beam with different holes for **LOCKING** the beam to a cross-axle and attaching a free-spinning connector pin as a handle.



36.6



36.7



STEP 36.7 TIP: CHANGING DIRECTION

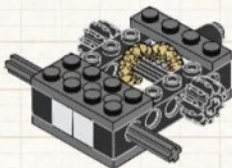
Placing two gears so they interact at a right angle changes the direction of a function's movement. Thanks to these two tan half-gears, when you turn the handle, the gear on the side will spin. Try it out and see!





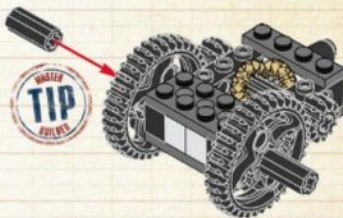
1x

36.8



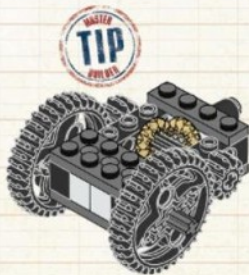
2x

36.10



2x

36.9



2x

36.11



4 1:1

**STEP 36.9 TIP: GEAR SIZE AND SPEED**

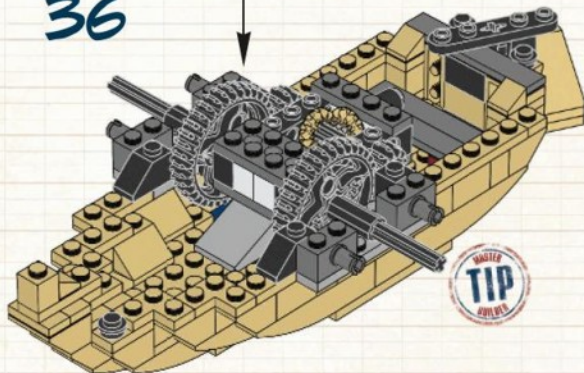
When a small gear moves a big one, you get a slow but powerful rotation. When a big gear moves a small one, you get a fast but weaker rotation. By combining gears of different sizes, you can change the speed and strength of your model's **FUNCTIONS!**

**STEP 36.10 TIP: AXLE EXTENDER**

Are your cross-axes too short for the function that you want to build? No problem! By using a cross-axle extension piece, you can connect additional axles end-to-end and make them as long as you want.



36

**STEP 36 TIP: TAKE IT FOR A SPIN**

If you've followed the steps precisely, then you've correctly assembled the geared mechanism for your model's function. But will it work? Attach the module to your boat and give the crank a test turn. If the big gears on the sides turn at the same speed and in the same direction, then you're all set to proceed!

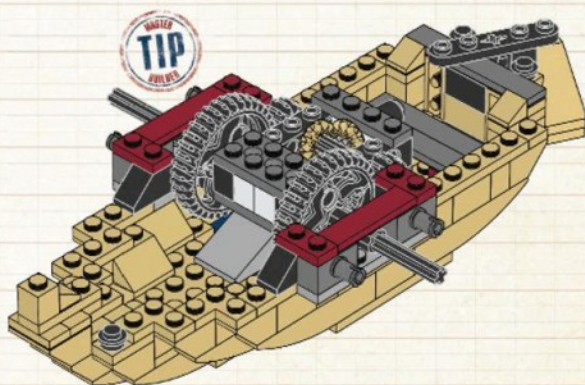




2X

4X

37



## A MULTI-USE MODULE

Because you've built this model's geared function as a separate module, you can use it for more than just paddle-boats. By following Steps 36.1 to 36.11, you can recreate the module any time you like and use it to give similar movement **FUNCTIONS** to your other LEGO® invention creations!



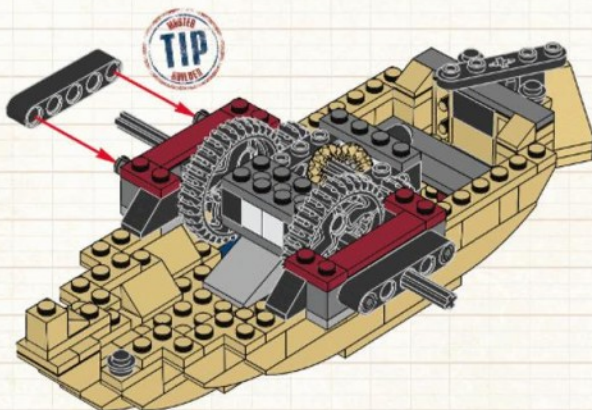
### STEP 37 TIP: SECURE YOUR FUNCTION

Now that you've confirmed that all of your function's moving pieces are lined up with each other right, you need to make sure that they stay that way. **LOCK** them down with some plates and tiles – and give the model a splash of **COLOR** at the same time.



2x

38

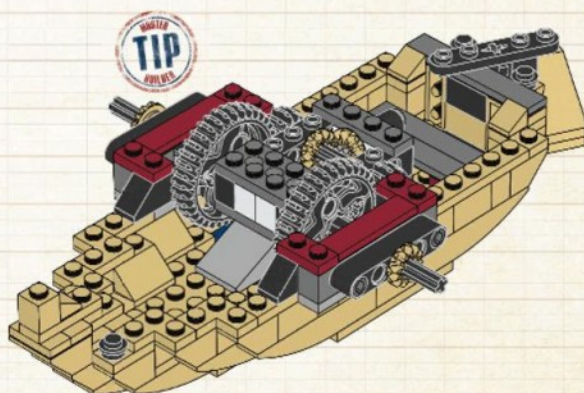
**STEP 38 TIP: SIDEWAYS SUPPORTS**

Long cross-axes need to be reinforced so that they don't bend and mess up the function – but they have to be able to rotate, too. Use **SIDEWAYS BUILDING** to attach two Technic beams as **SUPPORT ELEMENTS** that will hold the cross-axes in place while letting them spin smoothly!





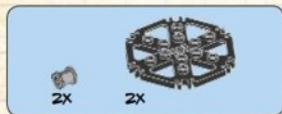
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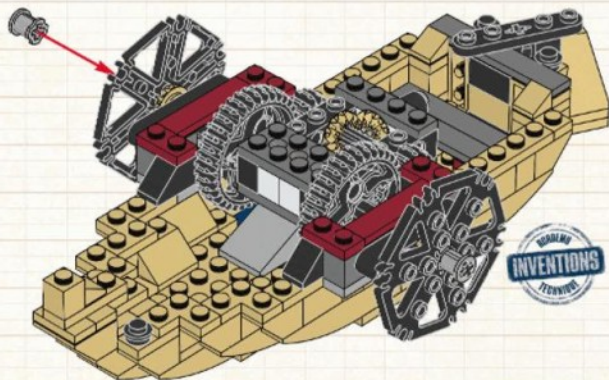
**STEP 39 TIP: ADD SOME DISTANCE**

You can use gears for more than mechanical movement. These ones will create a little bit of extra space between the Technic beams and the wheels that you'll be attaching in the next step. Now the wheels and beams won't scrape against each other and slow down the function's spinning.





40

**STEP 40 TECHNIQUE: INVENTIONS!**

You've created a working function for your model, but this invention isn't quite finished yet. Turning the crank makes the cross-axles on the sides spin, so what can you use the axles for? People use paddles and oars to move boats through water, but that takes a lot of effort. What you need is something like a whole bunch of paddles that work automatically – and these two big wheels will provide just the base you need.



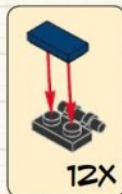


12X

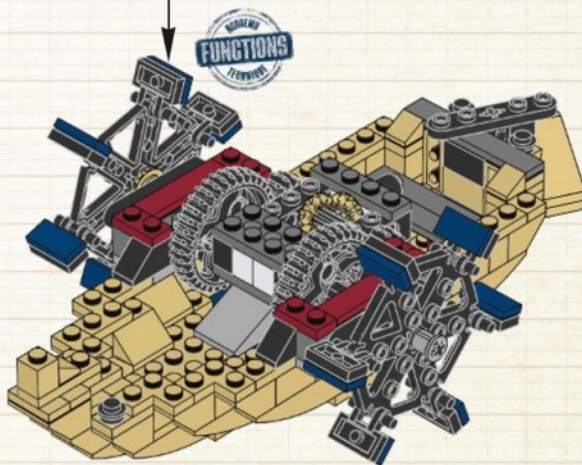


12X

41



12X



TURN THE CRANK AND SEE HOW THE PADDLE-WHEELS MOVE SLOWLY BUT POWERFULLY - OR TURN THE WHEELS TO SEE HOW THE CRANK SPINS AROUND FAST. CAN YOU COME UP WITH ANOTHER INVENTION THAT USES THE SAME FUNCTION, BUT IN REVERSE?

#### STEP 41 TECHNIQUE: FUNCTIONS!

Paddles push water to create movement, and more paddles mean more movement. To turn these wheels into paddle-wheels, combine twelve handle-bar plates with twelve smooth 1x2 tiles to create twelve identical paddles. Snap six of them onto each wheel so they stick straight out. Now you've got a working invention, just like Leonardo da Vinci!



45

Kit 12

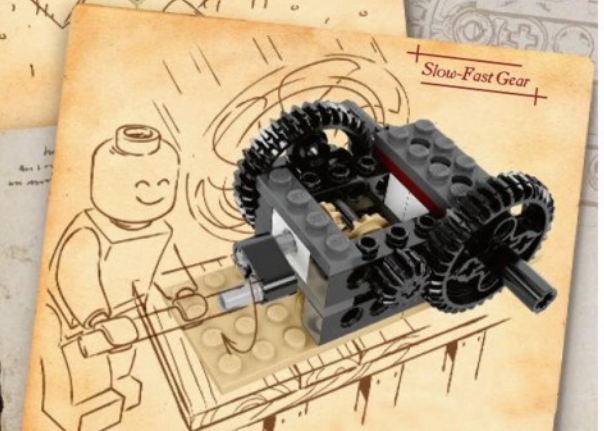
# SPRINGBOARD MODELS

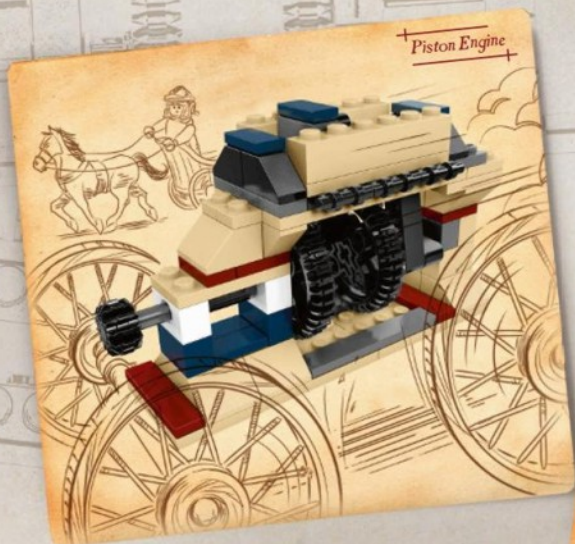
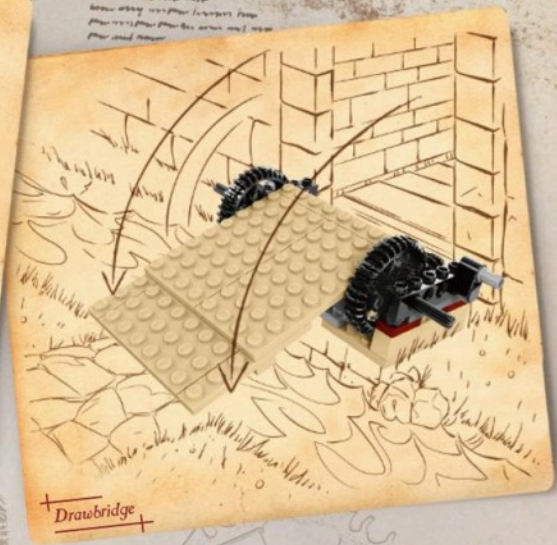
At the core of every great LEGO® invention is a special moving function. This kit's gear-powered springboard models will use the **INVENTIONS** and **FUNCTIONS** techniques to get you started on making your own amazing invention models!

Each of the Kit 12 springboard models was designed by the LEGO Master Builders to be a working mechanical module that you can build into an invention – but what kind of invention is up to you. You can take a flying machine springboard and add bricks to make a creature with flapping wings, or use a drawbridge springboard to create an elevating launch platform for a spaceship. The possibilities are limitless!

As you construct these springboard models using the pieces from this kit, you'll see how their LEGO® Technic elements work together to create different types of movement. Once you've had some practice, try changing the placement of their gears and cross-axles to design your own totally new and original functions.

You'll find building steps for three all-new invention springboard models on the following pages of your handbook, and instructions for seven more on the LEGO Master Builder Academy website!





YOU'LL FIND **BUILDING INSTRUCTIONS** FOR ALL OF THESE  
SPRINGBOARD MODELS AT YOUR **KIT 12 DESK** ON [LEGOmba.com!](http://LEGOmba.com)



## FOUR-WHEEL DRIVE

In a vehicle with four-wheel drive, all four wheels are rotated by the engine at the same time, providing the driver with more power and control over the vehicle's movement.

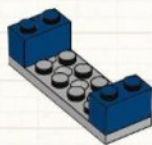
This springboard model will show you how to create gearing and axles for a four-wheel drive vehicle. Once you understand how the parts work together, you'll be able to build all kinds of different autos around the same function!



1



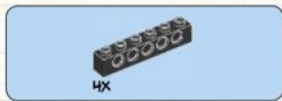
2



### STEP 1 TECHNIQUE: INVENTIONS!

Standard two-wheel drive vehicles (in which either the front or rear wheels are powered by the engine, but not both) can have trouble on uneven or muddy terrain. That's why the four-wheel drive system was invented! With this first plate, you're creating the foundation for your vehicle's entire chassis.

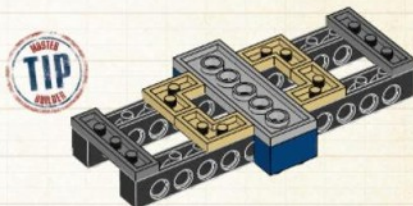




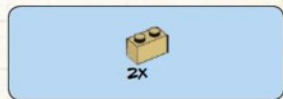
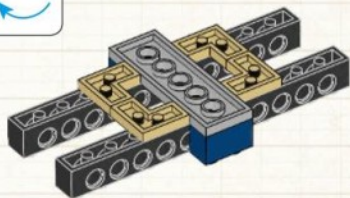
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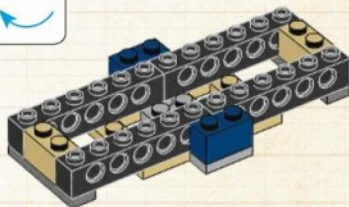
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4



6



### STEP 3 TIP: FRAMES WITH HOLES

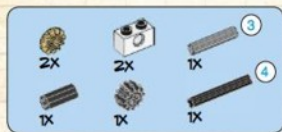
By building your invention's frame out of LEGO® Technic bricks with holes, you make it easy to create a mechanism that uses both **TECHNIC ELEMENTS** and basic bricks to make its special function work.



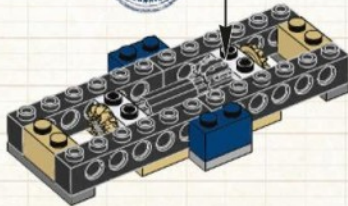
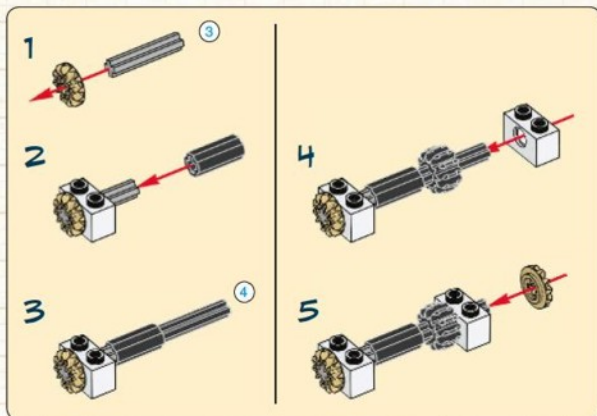
### STEP 5 TIP: STABLE SOLUTION

A chassis with parts that wiggle around can lead to a function that jams up or falls apart. Make sure this one moves smoothly by **LOCKING** the frame together in multiple places for **STABILITY**.





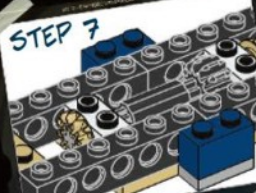
7



### STEP 7 TECHNIQUE: FUNCTIONS!

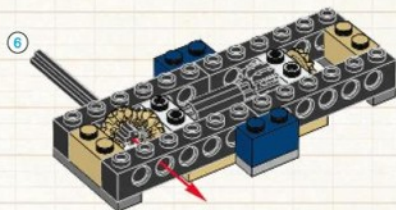
This is the central axle of your invention's function. Spinning the tan half-gear at one end makes the half-gear at the other end spin too, since they're both **LOCKED** onto a straight cross-axe that you've built out of two smaller ones so it's just the right length. The thicker black gear between them also makes both half-gears turn. By connecting it to another gear attached to a LEGO® Power Functions motor, you could even motorize the entire function!

STEP 7

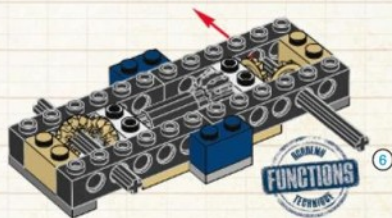




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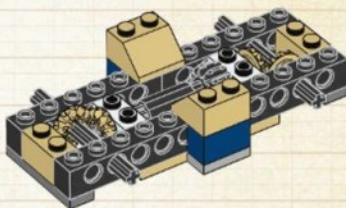


**STEP 9 TECHNIQUE: FUNCTIONS!**

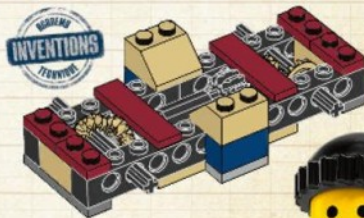
Why place these two tan half-gears on opposite sides of the frame? If you'd put them both on the same side, then the front and back wheels would have turned in opposite directions. But with one on the other side, its rotation is reversed so all four wheels spin the same way.



10



11



**STEP 11 TECHNIQUE: INVENTIONS!**

Your invention is complete! Now you can attach wheels and build an auto body around this module using what you learned in KIT 6!



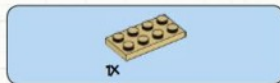
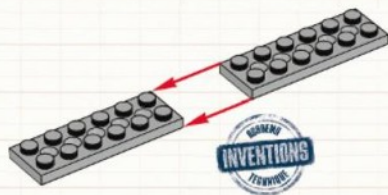
## HELICOPTER

A helicopter can take off and land vertically, hover in midair, and fly in all directions, making it a very flexible and useful aircraft – all thanks to the overhead rotor that spins to provide both lift and thrust.

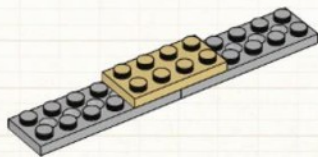
This springboard model will show you how to build an internal mechanism for a helicopter in which the top rotor is linked to a smaller tail rotor through a system of gears that changes the direction of movement from horizontal to vertical...and vice versa!



1

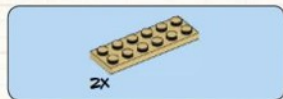


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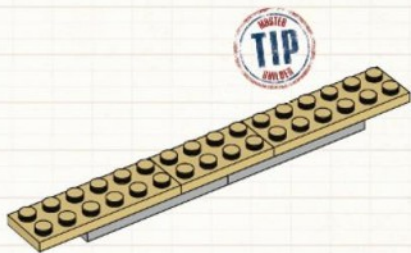


### STEP 1 TECHNIQUE: INVENTIONS!

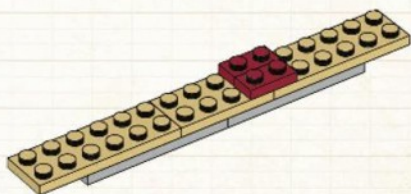
Before the discovery of powered aircraft, people long dreamed of creating machines that would let them take off into the air and fly. These two plates with holes are the start of the realization of that dream...for your LEGO® MBA Minifigure inventor, at least!



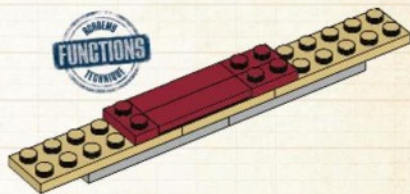
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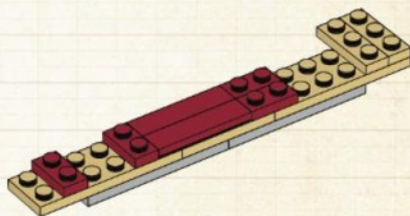
4



5



6



#### STEP 3 TIP: THIN AND STURDY

A helicopter needs a lightweight structure that isn't too heavy for its rotor to lift off the ground. Use narrow plates to **LOCK** together a platform that's long enough for your function without any unnecessary bulk.

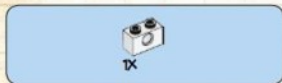


#### STEP 5 TECHNIQUE: FUNCTIONS!

Add **STABILITY** with just enough pieces to double-lock the platform so it doesn't bend and mess up your invention's function. The stud-less tiles in the middle of this layer will provide clearance for part of your rotor-spinning mechanism.



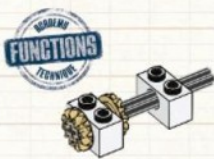
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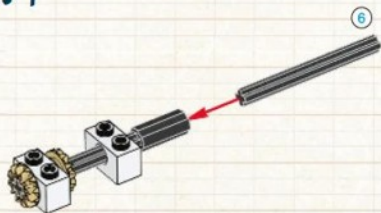
7.2



7.3



7.4

**STEP 7.1 TECHNIQUE: INVENTIONS!**

These two elements are the most basic components of a working function: the gear and the cross-axle. Combining them in different ways opens up endless options for new inventions!

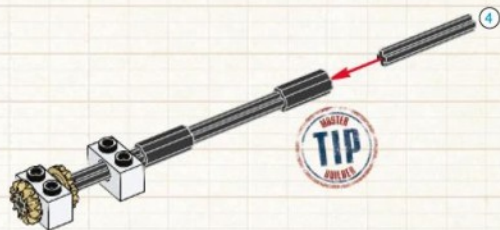
**STEP 7.3 TECHNIQUE: FUNCTIONS!**

Designing a functional mechanism is all about the careful positioning of gears. Placing this half-gear inside your invention will allow another gear to interact with it and rotate the attached cross-axle. Sandwiching the white LEGO® Technic brick with hole between two gears **LOCKS** it in place.

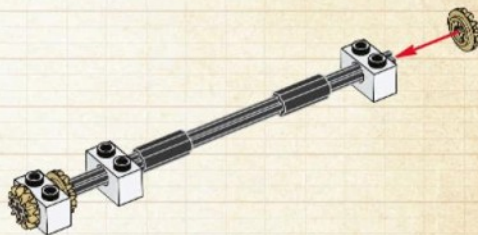




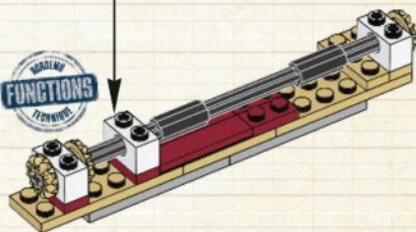
7.5



7.6



7



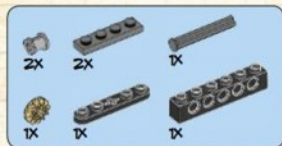
#### STEP 7.5 TIP: EXTEND YOUR MOVEMENT

Since the top and tail rotors of this helicopter will be rotating in different directions, you need to place them far enough apart that they won't hit each other. Use cross-axle extension pieces to assemble a long but sturdy axle that stretches the entire length of your model.

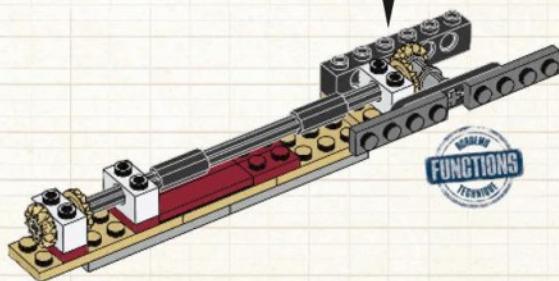
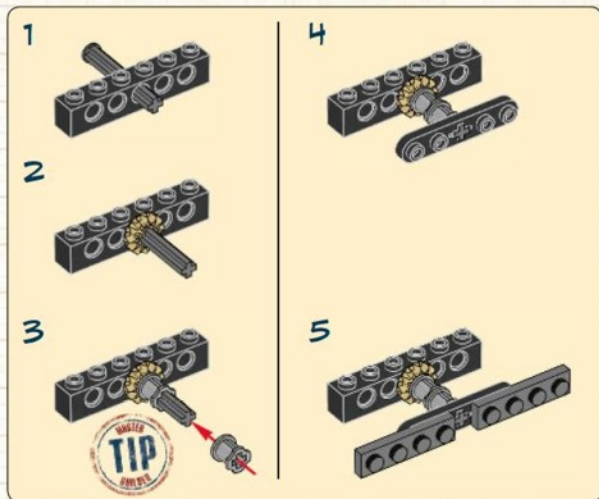


#### STEP 7 TECHNIQUE: FUNCTIONS!

Now that the first section of your helicopter mechanism is attached to the main platform, all of its different parts – bricks, gears, and cross-axes – are in exactly the right places to bring your function to moving life.



8

**STEP 8.3 TIP: MAINTAIN DISTANCE**

Slide two Technic bush elements onto this cross-axle to **LOCK** the half-gear in place and create the proper spacing for your helicopter's tail rotor to prevent it from bumping into any other parts of your model when it spins.

**STEP 8 TECHNIQUE: FUNCTIONS!**

Give your newly-attached tail rotor a test spin and see how your function is coming along. Thanks to the interaction of the two tan half-gears at the back, when the tail rotor's cross-axle rotates, its movement is transferred to make the long central axle rotate as well!





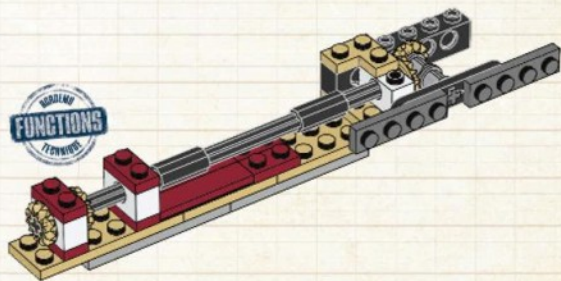


1X



2X

9



## LEONARDO'S HELICOPTER

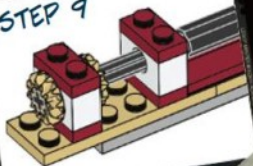
Like many modern inventions, Leonardo da Vinci thought of it first! The first true helicopters may not have flown until the 20<sup>th</sup> century, but back in the 1480s, Leonardo was already thinking about vehicles that could take off straight up into the air. Although he never built it, he created notes and sketches for a crank-powered "aerial screw" device made out of linen, reeds and wire!

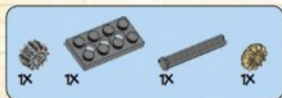


### STEP 9 TECHNIQUE: FUNCTIONS!

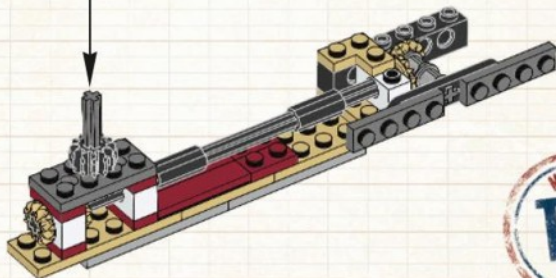
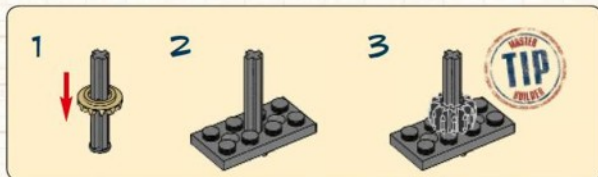
A function's parts need to line up properly in order to work together. These two dark red 1x2 plates will give you the height and clearance you need to attach the top rotor's gearing.

STEP 9





10



**BONUS TIP:**  
PLATES WITH HOLES ARE GREAT  
FOR BUILDING FUNCTIONS INTO  
YOUR BRICK CREATIONS!

#### STEP 10.3 TIP: NOT TOO TIGHT

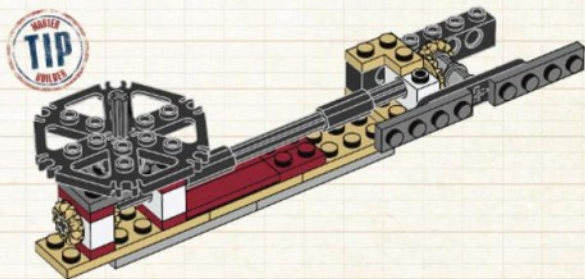
When building a LEGO® model, you usually want to snap the pieces together tightly for the best stability. If you're working with gears, though, an overly snug connection can slow down your function's movement. For smooth cross-axle spinning, make sure these two gears don't pinch the plate in between them too tightly.





1x

11



## CHANGING DIRECTIONS

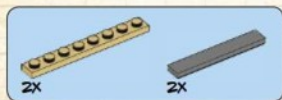
Changing the direction of movement in a LEGO® Technic function is as easy as changing the side a gear is on. When you turn your model's tail rotor, the top rotor will spin one way...but if you switched the placement of one of the half-gears, it would spin in the opposite direction!



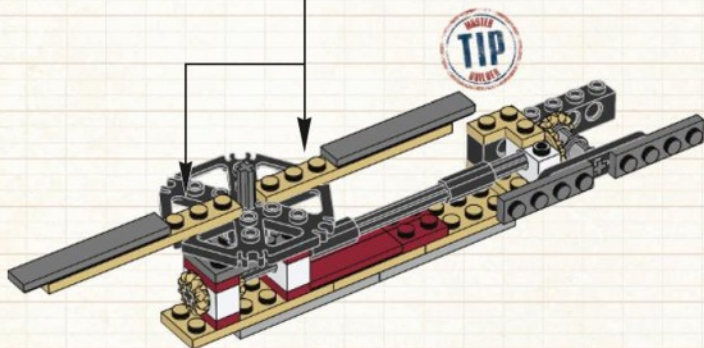
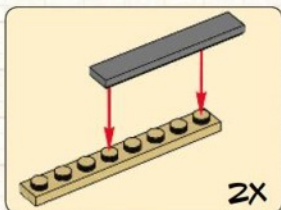
### STEP 11 TIP: LARGE ALTERNATIVES

One **LARGE ELEMENT** can have many **ALTERNATIVE USES**. On this kit's star model, this large wheel piece was the base of one of your boat's paddles, but on a helicopter it becomes the foundation of your main rotor.





12



#### STEP 12 TIP: EVERYTHING WORKS TOGETHER

In a working function, it's important to make sure that the many moving parts don't get in each other's way. If you make your helicopter's top rotor too long, it could smack into the tail rotor when they're both spinning. Want a longer top rotor? Just make its cross-axle longer so it has more clearance!

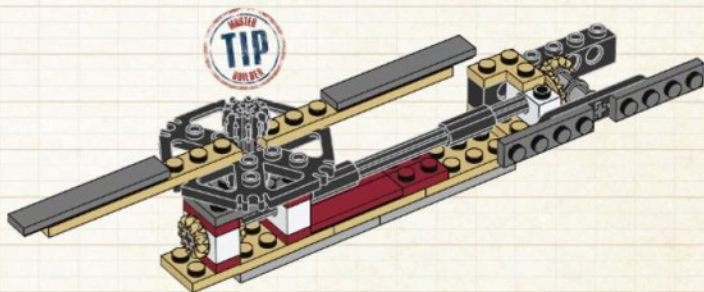




# 13



YOU'VE BUILT A FUNCTIONAL INTERNAL MECHANISM FOR A HELICOPTER WITH LINKED TOP AND TAIL ROTORS. NOW TRY USING YOUR LEGO® BRICK COLLECTION TO DESIGN THE REST OF THE VEHICLE AROUND IT!

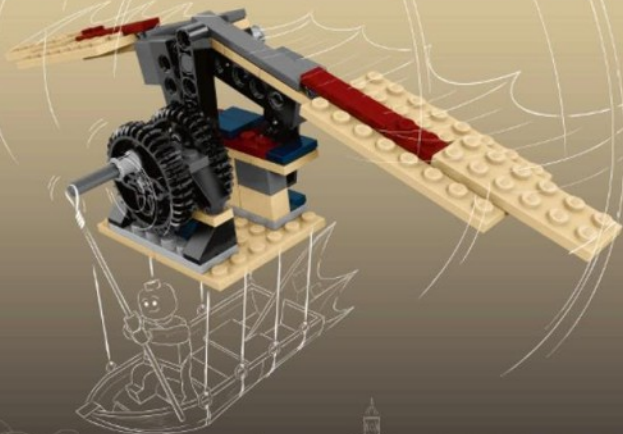


### STEP 13 TIP: TURN IT AROUND

To make sure your top rotor doesn't fly off in mid-flight, **LOCK** it down with a gear. The thick gear's ridged teeth also make perfect finger-grips for spinning the whole thing around. Pick up your new invention and try it out!



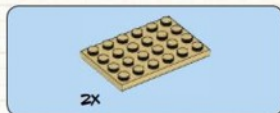
## three



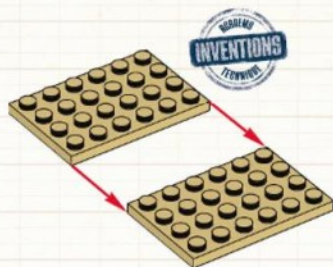
## FLYING MACHINE

You've seen and built everyday aircraft like helicopters and airplanes, but how about one that flies by flapping its wings up and down like a bird? These unusual flying machines are called ornithopters, and as fanciful as they may look, some of them really work.

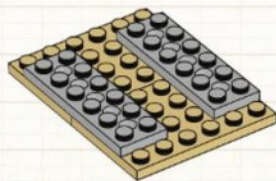
You've already practiced combining gears and cross-axes to create and redirect movement in your inventions. With this springboard model, you'll add beams and bricks to the mix for an even more advanced mechanical function!



1



2

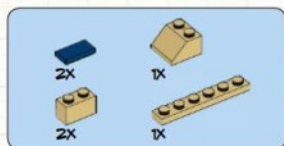
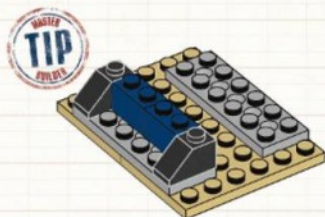


### STEP 1 TECHNIQUE: INVENTIONS!

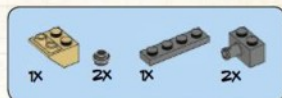
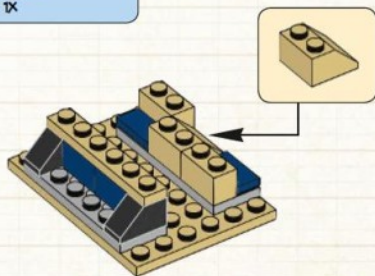
Long before the Wright Brothers learned to fly, Leonardo da Vinci studied birds. He looked at how their wings moved and how their bodies were put together. This inspired him to dream up numerous flying inventions, including one of the first ornithopter designs. To start building one of your own, put these two plates together!



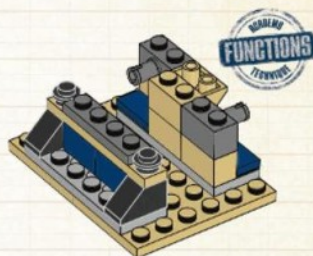
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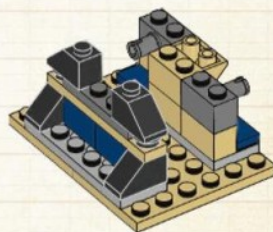
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5



6



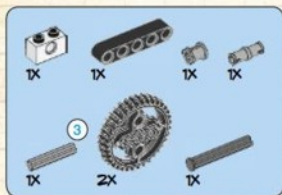
### STEP 3 TIP: THE STURDY SLOPE

Your flying machine needs giant wings, and to make them flap you'll need a strong and stable mechanism. For the best balance of **STABILITY** and free space for moving parts, use a pair of slope bricks as **SUPPORT ELEMENTS**.

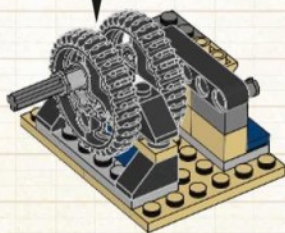
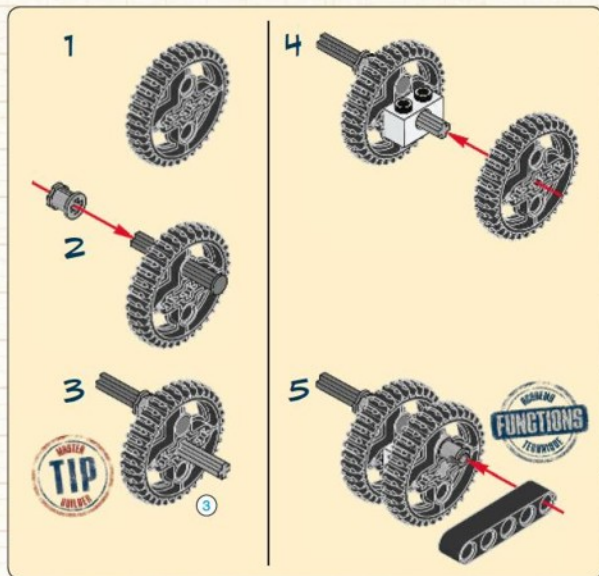


### STEP 5 TECHNIQUE: FUNCTIONS!

How do you control two wings with one mechanism? If they're exactly side-by-side, they'll bump into each other when they flap. Point these LEGO® Technic bricks with connector pins in opposite directions to make bases for wings that can work together.



8



### STEP 8.3 TIP: WHEN IS A GEAR NOT A GEAR?

Since this gear doesn't interact with any other gears, you're not actually using it as a gear. Instead, through the **ALTERNATIVE USES** technique, it will become a powerful hand-crank for your invention.

### STEP 8.5 TECHNIQUE: FUNCTIONS!

By placing this free-spinning Technic pin off-center in the gear, you can create asymmetrical movement. This means that any element you attach to the pin – like a Technic beam – will go left and right, or up and down, instead of round and round.



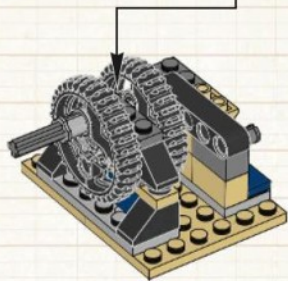




1x

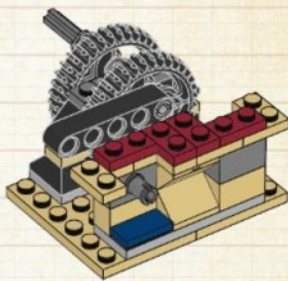


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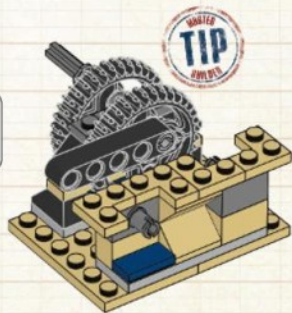
1x

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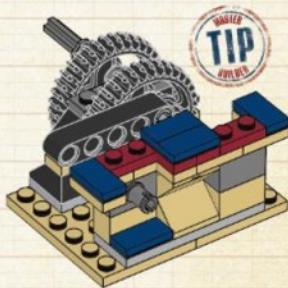
1x

10



1x

12



#### STEP 10 TIP: OPEN SKIES

These bent corner plates will **LOCK** this section of your model together while providing open space above the Technic pins below. Now whatever you attach to the pins will still have enough room to move.



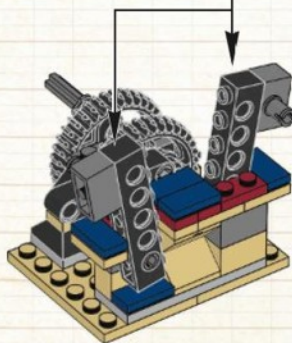
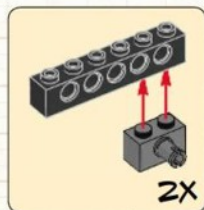
#### STEP 12 TIP: TILE PLATFORM

Smooth tiles in the middle add an extra level of **LOCKING** without any studs sticking up and getting in the way of your invention's moving parts.





13



## TAKE FLIGHT

Birds aren't the only animals that can fly. Take a look at how the wings of bats and insects work, too – maybe they'll inspire your next invention!



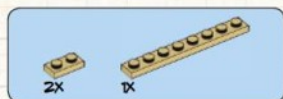
### STEP 13 TIP: LEARN FROM THE PROS

If you were designing this mechanism from scratch, you might stick connector pins into the holes on these 1x6 Technic bricks and then discover late in your build that the wings don't work quite right. Fortunately, the LEGO® Master Builders have saved you some trial-and-error rebuilding – attaching bricks with pins beneath the longer bricks will give you connectors in just the right spots and make sure your wings don't hit the ground when they flap!

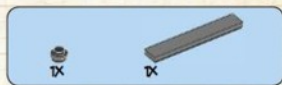
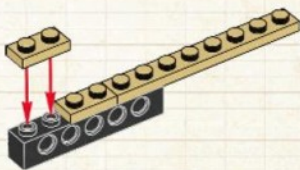




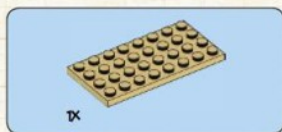
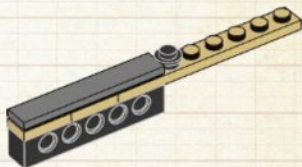
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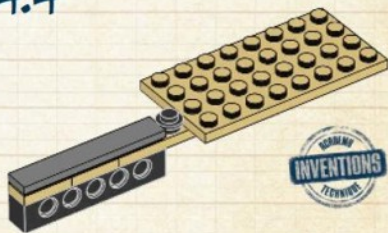
14.2



14.3



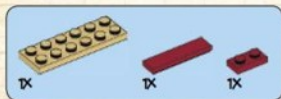
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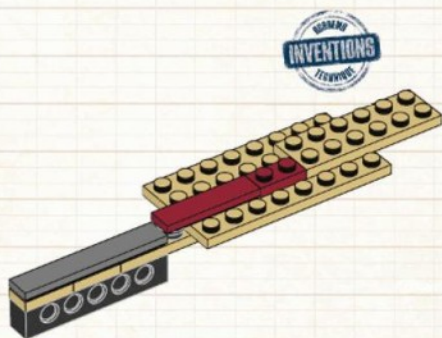
#### STEP 14.4 TECHNIQUE: INVENTIONS!

In the days before jet engines and motorized propellers, inventors designed flying machines with enormous wings in the hopes of capturing lots of air and creating enough lift to get off the ground. You can make your own **LARGE ELEMENTS** wing with a big 4x8 plate!





14.5

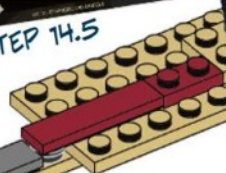


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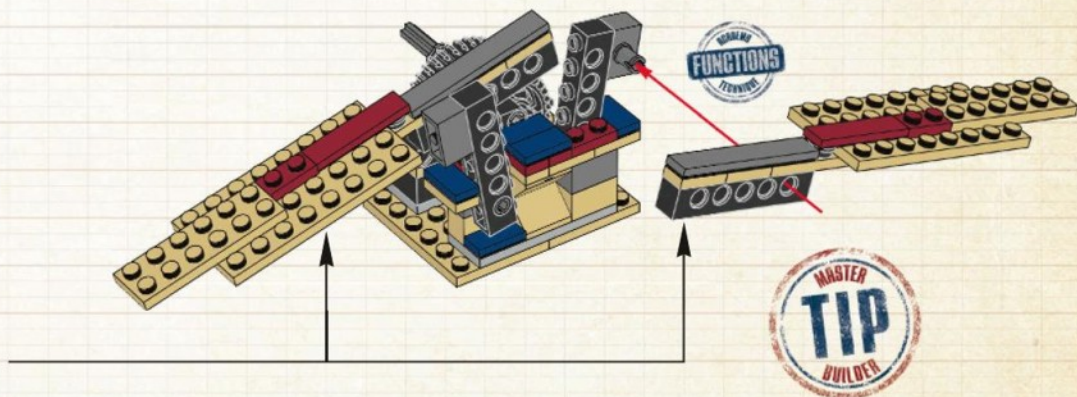
**STEP 14.5 TECHNIQUE: INVENTIONS!**

You've built one wing – now make a second one that's exactly the same! Since the wing isn't perfectly symmetrical, you might think that two identical ones would knock your invention off-balance, but in a moment you'll see how it all works out.

STEP 14.5



14

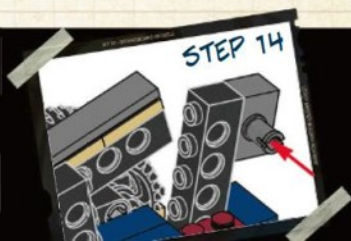


**BONUS TIP:**

PRECISION IS IMPORTANT FOR SMOOTHLY-MOVING FUNCTIONS, SO DOUBLE-CHECK THAT YOU'RE CONNECTING THE PINS TO THE RIGHT HOLES IN YOUR WINGS!

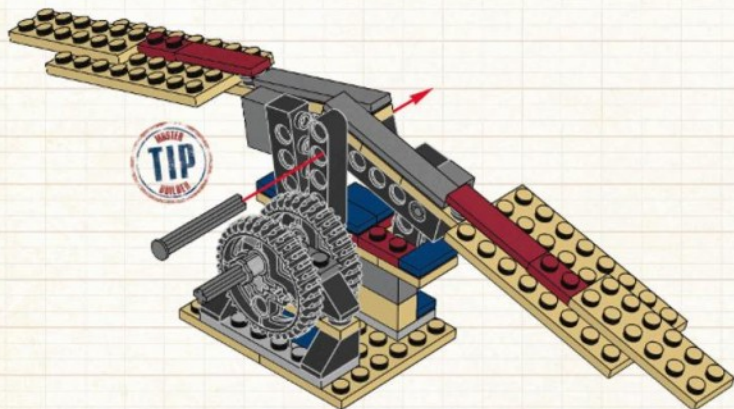
**STEP 14 TECHNIQUE: FUNCTIONS!**

Now you can see why the wings are duplicated instead of mirrored. Because their connection points are offset from one another, the opposite-facing wing edges end up lining up for a symmetrical overall flying surface!





15

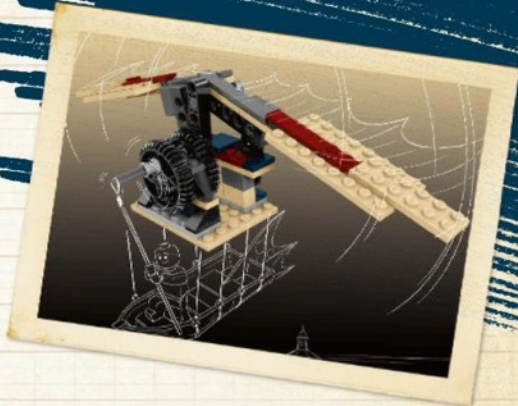
**STEP 15 TIP: TEST FLIGHT**

Use a cross-axle with a flat head to connect both wings to the Technic beam that you pinned onto the crank earlier. Make sure it goes through all three holes: the ones on the ends of the wings, and one down from the top of the beam. Turn the crank (slowly, since you haven't locked the cross-axle in place yet!) and test the model's function. Do both wings flap up and down smoothly? Then everything's put together right!

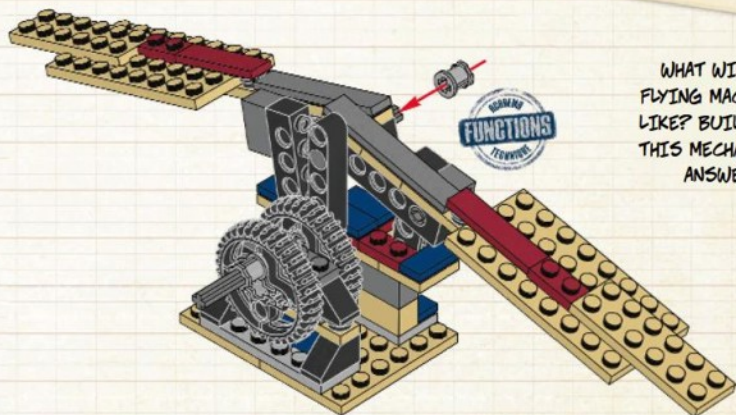


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16

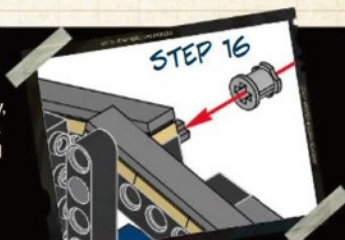


WHAT WILL YOUR COMPLETED FLYING MACHINE INVENTION LOOK LIKE? BUILD SOMETHING AROUND THIS MECHANISM AND DECIDE THE ANSWER FOR YOURSELF!



#### STEP 16 TECHNIQUE: FUNCTIONS!

Finally, secure everything in position by **LOCKING** the cross-axle with a Technic bush. Don't push it in too tightly, or the extra friction will make the movement of the wings stiff. You've just built the mechanism for an old-fashioned ornithopter – Leonardo da Vinci would be proud!

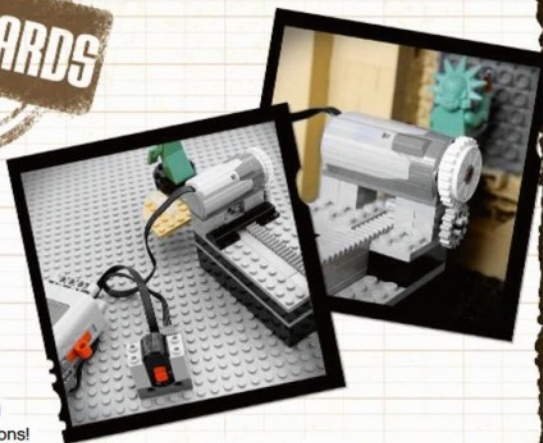


LEGO® Fan Creations!

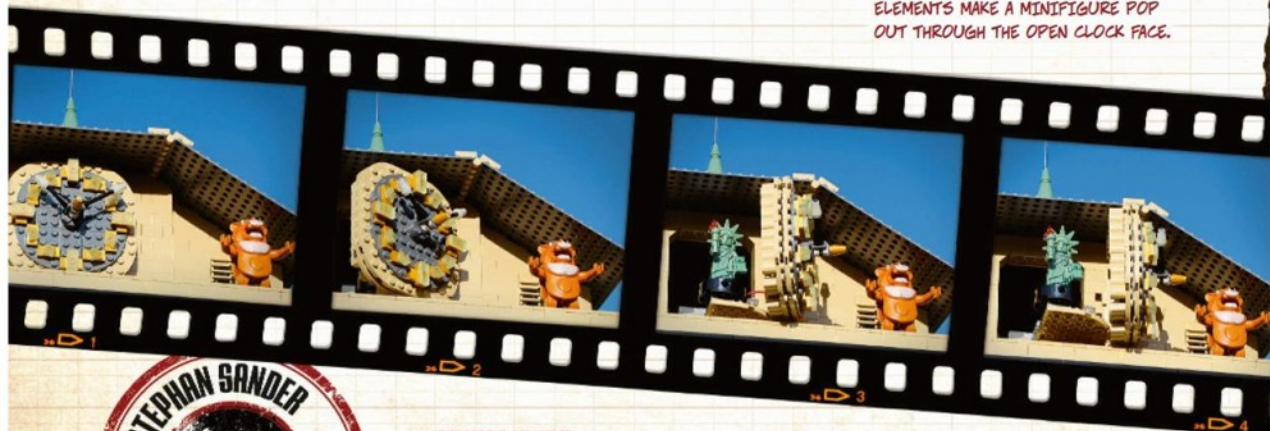
# INVENTIVE SPRINGBOARDS



Designing an invention springboard is all about creating the structure and moving parts of a functional mechanism – the actual model that will be built around it can come later! The two expert LEGO® fan builders featured here have transformed their own springboards into models with fun and surprising working functions. See if they give you any ideas for your own custom inventions!



LEGO® POWER FUNCTIONS ELEMENTS MAKE A MINIFIGURE POP OUT THROUGH THE OPEN CLOCK FACE.



## CUCKOO CLOCK

THE MINIFIGURE "CUCKOO" FOR THIS CLOCK MODEL IS CONTROLLED BY AN INFRARED TRANSMITTER. A SENSOR HIDDEN BEHIND A VENTILATION GRID PICKS UP THE INFRARED LIGHT AND TRIGGERS A SMALL POWER FUNCTIONS MOTOR TO MOVE THE GEAR BAR ATTACHED TO THE MINIFIGURE.

IT'S NOT IMMEDIATELY OBVIOUS THAT THE CLOCK CAN OPEN UP, GIVING THE INVENTION A BIGGER SURPRISE EFFECT.

YOU CAN EXCHANGE THE MINIFIGURE FOR ANYTHING ELSE THAT YOU LIKE. THE MORE UNEXPECTED, THE BETTER!





## SWINGING BOAT RIDE

WHO DOESN'T LIKE ANIMATED AMUSEMENT PARK RIDES? THIS MODEL SHOWS HOW TWO SMALL GEARS NEXT TO EACH OTHER ON THEIR AXLE CAN MAKE BIG MIRRORED SWINGING MOTIONS, JUST BY TURNING ONE OF THE AXLES BACK AND FORTH.



## TEACUP RIDE

Each cup spins individually while the entire ride rotates, thanks to turntables and gears connected to a gear that turns along with the model's base.



## ROTATING PILLARS

In this ninja obstacle course, the pillars are held in place by axles with a gear underneath. Linking the gears together lets you spin all of the pillars at the same time.



## SPINNING SWORDS

As in the teacup ride, a gear is connected to the movement of the base, and then gears connected to that gear spin the swords.

## CHOPPING AXES

A small LEGO® Technic bush is connected to the pulley wheel by an elastic band, which is connected to the large gear. The axes are attached to one of the outer holes, so that when the gear spins, the axes go up and down.

Kit 12

# INVENTION CHALLENGE!

## DESIGN AND BUILD A FUNCTIONAL INVENTION!

So far, you've followed the LEGO® Master Builders' tips and instructions as you've combined standard bricks with LEGO Technic elements to create advanced moving, working mechanisms. Now it's your chance to show off what you've learned by taking part in your final epic test for Level 4 – the Invention Design Challenge!

### THE CHALLENGE

Prove that you can design and build the LEGO Master Builder way by creating your own one-of-a-kind invention model! Use your collection of LEGO bricks, axles, beams and gears to make something with an interesting, useful, fun or unique mechanical function.

Remember to use the **INVENTIONS** technique to come up with an idea, and the **FUNCTIONS** technique to transform it into reality. Take multiple photos to show how your invention works and what it does!

### START INVENTING

To take part in the Kit 12 Design Challenge, you need to have registered your Level 4 membership at [www.LEGOmba.com](http://www.LEGOmba.com) using the code printed on page 5 of this handbook.

Once you're signed in on the website, visit your **KIT 12** desk, click on the **TO-DO LIST**, and select the **INVENTION DESIGN CHALLENGE**. Then just follow the instructions for taking and uploading pictures of your brand-new invention!





# INSIDE THE LAB

TIPS FOR DESIGNING INVENTION MODELS!



## 01. BE LIKE LEONARDO

Before coming up with a new invention, Leonardo da Vinci looked at the world around him. His ideas came from everything he saw and studied: animals, plants, rocks, water, and even colors and light. Pay attention to the way things work and you might just be inspired with your next big idea!

## 02. SKETCH IT OUT

Not many people can just sit down and make an invention. Before you start snapping bricks together and attaching gears to cross-axes, try making some design drawings of what your invention will look like when it's done, including all of its moving parts. The more you can visualize the way your model will work, the easier it will be to build!

## 03. FUNCTION FIRST

Now that you have a good direction for how the pieces will go together, start your build by constructing the mechanical function of your model. Don't worry about attaching wings or wheels or feet or extra decorations at this point; you'll have plenty of time to refine the details once you've figured out how to make your function work just right.

## 04. TEST AND RETEST

At each stage of your build, test your invention's function to make sure that all of the parts move smoothly, that nothing bumps or gets stuck, and that everything is locked together sturdily so that your model won't fall apart once it starts doing whatever you've designed it to do. If anything doesn't work quite right, figure out why and fix it before you continue building. Keep testing while you build, and you'll have a real working invention in no time!

YOU'LL FIND EVEN MORE **TIPS AND IDEAS** ON THE FOLLOWING PAGES AND AT YOUR **KIT 12 DESK** ON [LEGOmba.com](http://LEGOmba.com)!

# BRINGING MODELS TO LIFE

## HOW A LEGO® MASTER BUILDER INVENTS NEW FUNCTIONS!

You first met LEGO® Master Builder Adrian Florea in Kit 5 – Creature Designer. As a child in Romania, Adrian was fascinated by the clever tricks that his LEGO sets could do. Since getting his degree in Industrial Design, he has gone on to design models filled with working functions for the LEGO Ninjago and LEGO® Legends of Chima™ themes!

*"WHEN I DESIGN A MODEL, I LIKE TO CONCENTRATE ON COMING UP WITH A FUN FEATURE OR PLAY FUNCTION. IT'S HARD TO COME UP WITH A COMPLETELY ORIGINAL FUNCTION, BUT WHEN I DO, I KNOW THAT KIDS ALL AROUND THE WORLD WILL NOTICE IT. THE RULE I ALWAYS STICK TO IS THAT THE FORM AND FUNCTION NEED TO GO TOGETHER AND CREATE A STORY ONCE THE MODEL IS FINISHED. A GOOD FUNCTION MAKES THE MODEL FEEL ALIVE!"*

- LEGO DESIGNER ADRIAN FLOREA



### EARTH DRAGON DEFENSE

Building Rocky the Earth Dragon for the Ninjago theme gave me the opportunity to try out a new look and function. Along with lots of articulation for posing and defensive plates around his neck, I gave him a thick tail that he could use as a weapon.

I connected the tail to the body with a LEGO® Technic element that is usually used in the steering mechanisms of motorcycle models. The loose, flexible joints along the length of the tail mean that when you twist the gear at its base, the spikes on the end swing back and forth to attack enemies. I had to make sure I designed the tail so that its pieces held together while it was swinging around!

## EPIC DRAGON BATTLE

Using gravity is a fun way to make functions, so that just lifting your model makes parts slide or open to reveal hidden traps or treasures. When giving life to the four-headed Ultra Dragon, I didn't want to repeat any functions from the other Ninjago dragons. I looked around and noticed that nobody had made flapping wings yet. For the function that I came up with, the dragon's body is tied to its wings with pulleys, so that when you pick the model up by the handle on its back, the wings automatically spring open by themselves.

A big challenge was getting the angle of the wings just right so that they looked good both when open and closed. If the pulleys moved past the pivot point, then the wings would have popped off when the dragon was placed back down on the ground.

WINGS CLOSED - MODEL AT REST



WINGS OPEN - MODEL IN FLIGHT



## LENNOX'S LION ATTACK

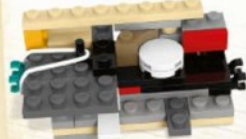
Functions are fun whether they are passive, defensive, or offensive, but there's no doubt that shooting functions are some of the coolest. For this Legends of Chima set, I hid a disc launcher inside the lion vehicle. Getting the mechanism to fit inside an 8x4-stud space including a rubber band took some time to develop. Once I had the discs working well, I realized that the model's plate layers would split apart during rough play, so I locked them together using Technic beams on each side.

When building shooting functions, the best part is the surprise effect. Activating a weapon in an unexpected way can be tricky, but the result feels much more rewarding. Systems that use rubber bands can be quite powerful, but they take up a lot of space and are best built into vehicles or turrets. Just remember to only fire them at LEGO brick targets!

DISC LAUNCHER READY TO FIRE!



DISC LAUNCHER FIRED!



SEE MORE TIPS FROM THE LEGO® MASTER BUILDERS  
IN YOUR **KIT 12** DESIGN JOURNAL AT [LEGOmba.com!](http://LEGOmba.com)

# MECHANICAL MOVEMENT

## A CLOSE-UP LOOK AT LEGO® TECHNIC FUNCTIONS!

The LEGO® Master Builders who design LEGO Technic sets are some of the most talented brick engineers in the world. Thanks to their years of experience and their inventive imaginations, they can build almost any kind of moving, working function out of basic beams, gears, cross-axes and other elements.

These function modules all come from official Technic models. Now that you've had some practice building the inventions in this handbook, look at the modules through the eyes of a LEGO Master Builder and see how all of the parts interact and work together to create each function's special movement!



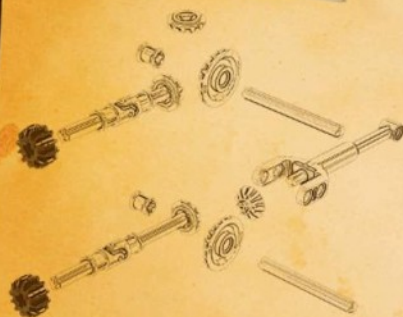
### STEERING FUNCTION



Off-Roader



### ARM-EXTENDING FUNCTION



Backhoe Loader





## SPINNING FUNCTION



Tractor



## LANDING GEAR FUNCTION



Jet Plane



CAN YOU SEE HOW EACH MOVING FUNCTION WORKS? THEN TAKE WHAT YOU'VE LEARNED AND START BUILDING YOUR OWN INVENTIONS!

LEGO® Fan Creations!

# MAKING MOTION

When he was young, fan builder Jason Allemann loved putting together LEGO® Technic sets and creating vehicle models with moving, working parts like steering systems, engines, and gear shifts. Today, his fascination with models that move inspires him to create his own function-filled LEGO inventions!

"I AM ALWAYS LOOKING AT THINGS THAT MOVE IN INTERESTING AND UNIQUE WAYS TO SEE HOW THEY WORK, AND IN THE BACK OF MY MIND, I THINK ABOUT HOW I MIGHT RECREATE THAT MOTION USING LEGO® ELEMENTS."

- JASON ALLEMANN



## DRUMMING FINGERS

Do you ever drum your fingers on the table? I wanted to build a LEGO model of a hand that did just that, with each finger moving up and down one after the other.

Before starting to build, the first thing I do is look for ways of achieving the motion I'm interested in creating. I often look at objects in the real world to see if anything else moves in a similar way. Sometimes I have to do a little research, either in books or on the internet. In this case, the movement that I wanted for the fingers was very much like how the pistons in the engine of a car move, traveling up and down in a specific sequence. I decided to



try and use this technique for this model. The next step was to build a prototype. At this point I usually focus only on the motion and don't think at all about how the final model might look. The first prototype I built was very simple, with a central rotating shaft of Technic pieces connected to some lift arms. Rotating the central shaft made the lift arms move up and down just the way I wanted. I then built a second prototype, taking into account how big I wanted the fingers to be, how much I wanted them to move up and down, and where I wanted the knuckles and table top to be. I often make several prototypes for my models, trying different things and refining the movement a little more each time.

Now that I had the motion sorted out, it was time to start working on the final model. I decided to build a red table and a hand with bent lift arms for fingers, but I just wasn't happy with how they looked. A friend suggested I try building the fingers using plates instead. I was much more satisfied with the new finger design and decided on a hand on a black box with a white tiled top. Don't be afraid to go back to the drawing board and redesign what you are building if you aren't happy with it. Most of the time, you will end up with a better model in the end.



## MOUSETRAP

I also like to build working models that can be used in everyday life. When I had a mouse loose in the house, I set out to build a trap that would catch it without harming it so I could move it outside. The first trap I built didn't work very well at all, and the mouse ended up escaping. I learned from my mistakes, though, and set out to build a better mousetrap. If at first you don't succeed, try again!

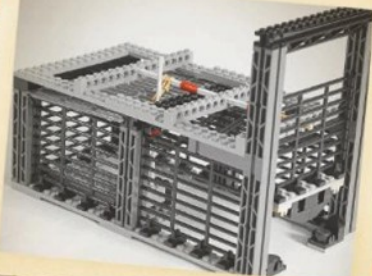
This trap is basically a large cage with a sliding gate on the front. There is a plate in the back of the cage, which is hinged using some LEGO pins. A bar is attached to the plate so that when the mouse steps on the plate, the bar pulls an axle from out of the front gate. The gate then falls and is held closed by some magnets.

The new trap was a great success, and I caught the mouse the first night I set it up!

## MARBLE MAZE

This model is a LEGO brick version of the popular wooden puzzle, where you try to guide a marble through a maze by tilting the surface using two control wheels. When building a LEGO version of something that already exists, it isn't necessarily as straightforward as duplicating the motion exactly with LEGO elements.

The wooden version uses a string wrapped around a shaft to control the tilt of the maze. This technique didn't work very well with LEGO parts, so I tried building several different prototypes of the control mechanism. I finally came up with a system of axles and link arms that was responsive enough to work. The LEGO system is extremely flexible, and if one way of building something isn't working, I just try something else.



I also added several new features to my version, including interchangeable mazes, an integrated container to store the marbles, and a locking mechanism to keep the maze from moving during travel. The great thing about building your own version of something is that you can customize it however you like.



# YOUR JOURNEY CONTINUES!

## THE BUILDING ADVENTURE NEVER ENDS!

As a member of the LEGO® Master Builder Academy, you've learned the skills of the LEGO Master Builders and trained in the exact same techniques that the official LEGO model designers use when they create new sets and themes. So what's the next step on your journey to better building?

If you haven't yet tried the other levels of LEGO MBA, then check them out! From spaceships to creatures to entire worlds of adventure, you'll be amazed at what you can learn to make.

If you've completed every level of LEGO MBA so far, then your next tip from the LEGO Master Builders is to keep building and participating on [LEGOmba.com](http://LEGOmba.com)! Use what you've learned in this program to design anything you can imagine, and bring it to life with your bricks.

The ultimate secret to building like a LEGO Master Builder is to never stop being creative. Experiment, improve, and invent your own building tricks and techniques. Above all else, remember that even the best LEGO builders can learn something new – just like we do all the time!

## KEEP ON BUILDING!

– THE LEGO® MASTER BUILDERS



# KIT 12 INVENTION DESIGNER ELEMENTS!

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| <br>12x<br>6030729  | <br>4x<br>4113917   | <br>2x<br>6030718   | <br>2x<br>4650498   | <br>1x<br>4211760 |
| <br>4x<br>4113015   | <br>6x<br>4114077   | <br>12x<br>4140588  | <br>1x<br>9336      | <br>2x<br>4211622 |
| <br>3x<br>4109995   | <br>3x<br>4121921   | <br>1x<br>414689    | <br>1x<br>6006402   | <br>1x<br>4211807 |
| <br>2x<br>4162465   | <br>1x<br>4114309   | <br>2x<br>4539442   | <br>1x<br>6012833   | <br>1x<br>4211815 |
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| <br>3x<br>4516055   | <br>2x<br>4113993   | <br>1x<br>474026    | <br>16x<br>4528488  | <br>2x<br>4211001 |
| <br>10x<br>4150196  | <br>2x<br>4114324   | <br>1x<br>459926    | <br>7x<br>4539007   | <br>2x<br>4227398 |
| <br>2x<br>4121972   | <br>3x<br>4114001   | <br>2x<br>4142135   | <br>1x<br>4550189   | <br>3x<br>4210651 |
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| <br>8x<br>4114322   | <br>5x<br>4565452  | <br>2x<br>4512363   | <br>1x<br>4211421  |  |
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