ENGINEERING MAKERSPACE

GEARED-UP GADGETS

創客工程

齒輪彈力組

EXPERIMENTS

7443

114 PCS

6+

STEAM

LEARN ABOUT GEARS AND TRANSMISSIONS

了解齒輪傳動的原理

5 MODELS TO BUILD

TABLE OF CONTENTS 目錄

On page 7 you can see all the models at a glance.
在第 7 頁上，您可以一目了然地看到所有模型。

Learn amazing information about gears pages 5 and 29.
在第 6 頁和第 30 頁上，了解有關齒輪的驚人信息。

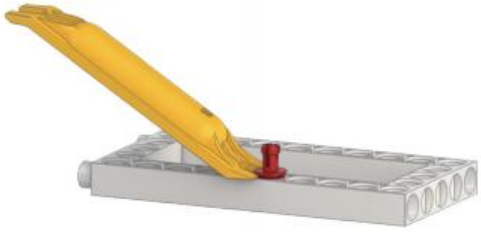
TIPS FOR ASSEMBLY
組裝小技巧

PEG REMOVER
扳手

Side A of the lever can be used to easily remove pegs.
扳手的 A 面可以用來輕鬆拆卸結合鍵。

For more assembly tips, please refer to
更多組裝小技巧，請參考

Side B can be used to loosen firmly inserted parts, such as axle.
B 面可用於鬆開牢固插入的部件，如自轉軸鍵 。



SAFETY INFORMATION 安全資訊

Warning! Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled.
Keep the packaging and the instructions as they contain important information.
Store the experiment materials and assembled models out of the reach of small children.
The models are intended for indoor use. Do not use your models in a sandbox. Do not use the hand mixer with food.
Clear sufficient space before launching the models. Keep small children or animals away when launching the models (in order to prevent nearby objects from breaking).

警告！本套組不適合 3 歲以下的幼童使用。其中包含細小零件可能被幼童吞嚥或吸入，產生窒息危險。
因內含重要訊息，請將包裝盒與說明書妥善保存。
請將實驗材料和組裝模型存放在幼童無法取得之處。
請在室內環境中遊玩，勿在沙坑中使用本套組的模型。手持攪拌器為仿真模型，請勿用於食物攪拌。
啟動模型前請確保有足夠的空間讓模形作動。模型作動時，請遠離幼童及動物（以免受傷）。

Dear Parents and Supervising Adults,

Before starting the experiments, read through the instruction manual together with your child and discuss the safety information. Check to make sure the models have been assembled correctly, and assist your child with the experiments.

We hope you and your child have a lot of fun with the experiments!

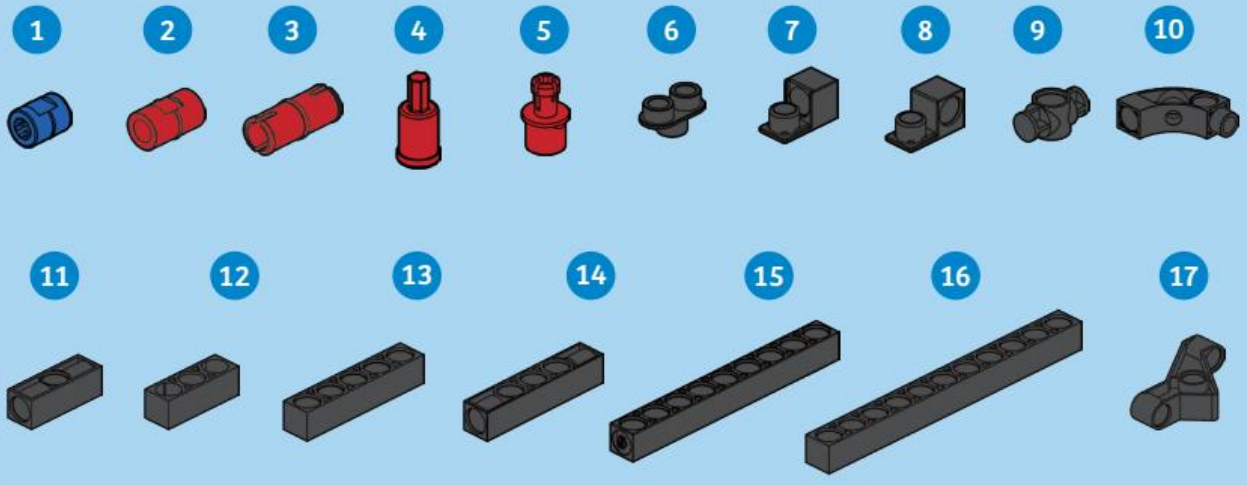
親愛的父母：

在實驗開始之前，請仔細閱讀使用說明書並和您的孩子一起討論安全資訊。請仔細檢查模型以確保有將模型正確組裝，並協助您的孩子進行實驗。

我們希望您和您的孩子在使用本套組時能獲得樂趣與完成有趣的實驗！

KIT CONTENTS 包裝內容

What's inside your experiment kit: 你的實驗包裡面有什麼零件呢？

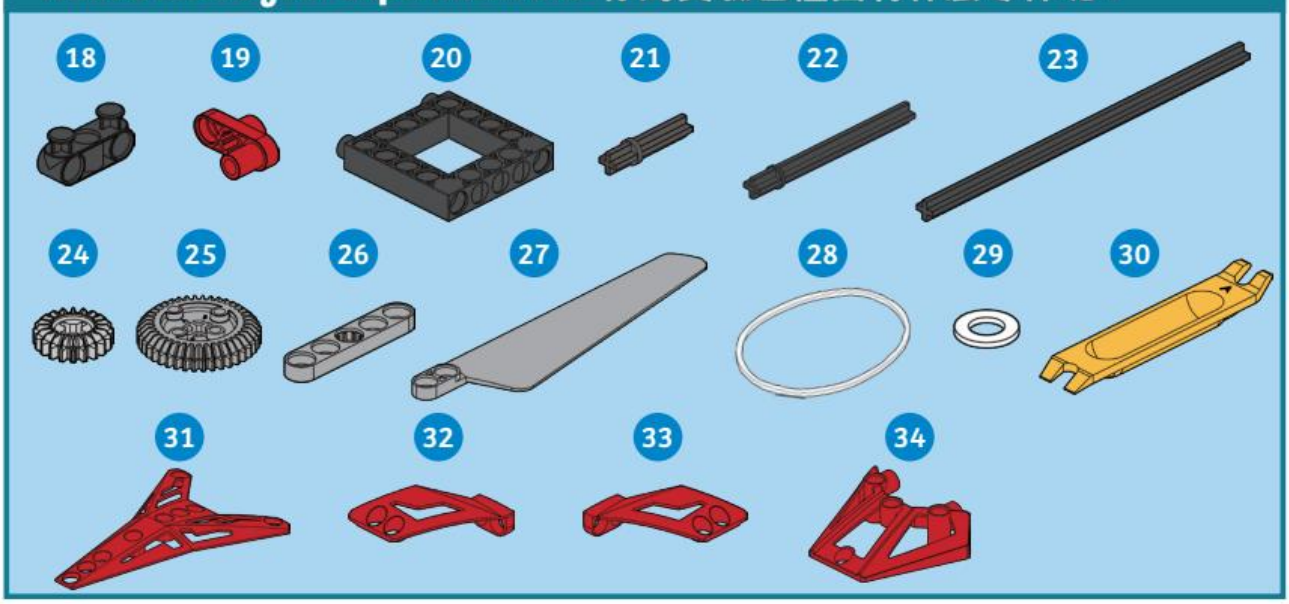


Checklist: Find – Inspect – Check off 清單：查找 - 檢查 - 核對

✔	NO. 號碼	Description	零件名稱	QTY. 數量	ITEAM NO. 品號
◯	1	B-SHORT PEG	B- 短結合鍵	30	7344-W10-C2B
◯	2	C-LONG PEG	C- 長結合鍵	10	7061-W10-C1R
◯	3	C-20mm AXLE CONNECTOR	C-20mm 軸扣鍵	3	7413-W10-T1R
◯	4	C-CAM CONNECTOR	C- 凸輪連結鍵	1	7413-W10-S1R
◯	5	C-AXLE	C- 自轉軸鍵	2	7026-W10-H1R
◯	6	C-TWO-IN-ONE CONVERTER	C- 二合一結合鍵	2	7061-W10-G1D
◯	7	C-FRONT CONVERTER	C- 單向轉接鍵	4	7061-W10-Y1D
◯	8	C-LATERAL CONVERTER	C- 雙向轉接鍵	2	7061-W10-X1D
◯	9	C-1 HOLE CONNECTOR	C-2 凸單孔轉向結合器	6	7430-W10-B1D
◯	10	C-BENDED ROD	C-3 孔 1/4 弧長條	2	7061-W10-V1D
◯	11	C-3 HOLE ROD FRONT CLOSED	C-3 孔長條側有孔	4	7026-W10-X1D
◯	12	C-3 HOLE ROD	C-3 孔長條	3	7026-W10-Q2D
◯	13	C-5 HOLE ROD	C-5 孔長條	3	7413-W10-K2D
◯	14	C-5 HOLE ROD FRONT CLOSED	C-5 孔長條側有孔	4	7413-W10-R1D
◯	15	C-9 HOLE ROD	C-9 孔長條	1	7407-W10-C1D
◯	16	C-11 HOLE ROD	C-11 孔長條	2	7413-W10-P1D
◯	17	C-TRIANGLE CONNECTOR	C-3 孔曲形條	4	7404-W10-B2D

KIT CONTENTS 包裝內容

What's inside your experiment kit: 你的實驗包裡面有什麼零件呢？



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✔	NO. 號碼	Description	零件名稱	QTY. 數量	ITEAM NO. 品號
◯	18	C-3 HOLE DUAL ROUND ROD WITH PEGS	C-2 凸 3 孔 90 度結合器	1	7404-W10-B1D
◯	19	C-3 HOLE CRANK	C-3 孔曲軸	2	7409-W10-H1G
◯	20	C-5X5 FRAME	C-5×5 孔正方框	3	7413-W10-Q1D
◯	21	C-35mm AXLE II	C-35mm II 軸	1	7413-W10-O1D
◯	22	C-70mm AXLE II	C-70mm II 軸	2	7061-W10-Q1D
◯	23	C-150mm AXLE I	C-150mm I 軸	1	7026-W10-P1D
◯	24	C-20T GEAR	C-20T 齒輪	5	7026-W10-D2S
◯	25	C-40T GEAR	C-40T 齒輪	1	7346-W10-C1S
◯	26	C-5 HOLE PROLATE ROD FOR AXLE	C-5 孔圓角扁長條（軸）	2	7443-W10-C2S
◯	27	C-HELICOPTER BLADE	C-L 型飾片	2	7443-W10-B1S
◯	28	C-70mm RUBBER BAND	C-70mm 橡皮筋	2	R10-02
◯	29	C-WASHER	C- 墊片	1	R12#3620
◯	30	B-PEG REMOVER	B- 扳手	1	7061-W10-B1Y
◯	31	C-LARGE BODY PIECE A	C-N 型飾片	2	7446-W10-A1R
◯	32	C-SMALL BODY PIECE LEFT	C-O 型飾片（左）	1	7446-W10-A2R
◯	33	C-SMALL BODY PIECE RIGHT	C-O 型飾片（右）	1	7446-W10-A3R
◯	34	C-LARGE BODY PIECE B	C-K 型飾片	3	7443-W10-A1R

CHECK IT OUT 知識補給站

Hold two of the gear wheels together, so that the cogs on the edges (the "teeth") interlock. Turn one of the wheels. The other wheel will turn as well, automatically moving along with the first gear. This demonstrates that interlocking gear wheels can transmit a rotational movement.

Pay close attention to the direction of rotation: The second wheel turns differently than the first one.

When the gear wheels have different diameters and, as a result, a different number of teeth, their rotational speeds will also be different. The larger wheel turns slower than the smaller one.

This shows that gear wheels can be used to convert a slow rotational movement into a faster rotational movement and vice versa. For example, if the larger gear wheel has 40 teeth and the smaller wheel has 10, the smaller wheel will complete 4 rotations in the time it takes the larger wheel to do one rotation. This relationship between the input speed and the output speed is known as the gear ratio. In this case, the ratio is 1:4.

>>> Use your other hand to slow down the second gear wheel while you turn the first wheel. You will notice that you need to apply a lot of force. This shows that interlocking gear wheels also transmit force.

>>> In the field of engineering, two or more interconnected gear wheels are called a gear train, or transmission. They come in many different shapes and sizes.

Two gear wheels on parallel shafts are known as spur gears. If you want to transmit a rotational movement to an axle standing perpendicular to the gear wheel, you can use a bevel gear (you'll use two of those for your helicopter model).

Before building any of the models, you should carry out the following little experiment.

It's also possible to arrange multiple gear wheels one after the other to convert a slow rotational movement into one or multiple very quick rotational movements — as you'll see when making the hand mixer model.

>>> Bicycles generally have a chain drive, in which gear wheels of various sizes are connected by a chain.

Gear trains can be found inside many machines and devices. For example, in mechanical clocks, the kind you might see in a museum, gear wheels enable the movement of a gear wheel propelled by a spring or weights to be transmitted to the hands of the clock. Thanks to the different gear ratios, the hands can move quickly (the second hand), slowly (the minute hand), or even slower (the hour hand).

This means that you can usually choose between multiple "gears," that is, you can switch between various different gear ratios.

This has a significant advantage, as gear trains don't just transmit rotational speeds, they also transmit force. Cycling is easiest when you can keep pedaling at the same speed. If you want to cycle over flat terrain or downhill, you can switch into a high gear in the rear. This connects the crankset with a much smaller gear on the rear wheel. The force from the pedals is converted into a much greater driving force making the bike move faster.

If you're cycling uphill, you can switch to a large gear in the rear and a small gear in front. This allows you to apply a smaller force on the pedals and turn them at a faster rate but the rear wheel will rotate a larger amount.

在構建任何模型之前，您應該執行以下小實驗。

CHECK IT OUT 知識補給站

將兩個齒輪固定在一起，以便邊緣上的輪齒互鎖。 轉動其中一個齒輪。另一個齒輪也會轉動，隨著第一個齒輪自動移動。這表示互相嚙合的齒輪可以傳遞旋轉運動。

密切關注旋轉方向：第二個齒輪與第一個齒輪不同。

當齒輪具有不同的直徑並因此具有不同數量的輪齒時，它們的旋轉速度也將不同。較大的齒輪旋轉速度較慢。

這表明可以使用齒輪將慢速旋轉運動轉換為更快的旋轉運動，反之亦然。例如，如果較大的齒輪具有 40 個齒並且較小的齒輪具有 10 個齒，則較小的齒輪將在較大的齒輪轉動一圈所需的時間內完成 4 個旋轉。輸入速度和輸出速度之間的這種關係被稱為齒輪傳動比。在這種情況下，比例是 1：4。

>>> 在轉動第一個齒輪時，用另一隻手放慢第二個齒輪。你會注意到你需要施加很大的力量。 這表明互鎖齒輪也能傳遞力。

>>> 在工程學中，兩個或更多個相互連接的齒輪被稱為齒輪系或傳動機構。齒輪有許多不同的形狀和大小。

平行軸上的兩個齒輪稱為正齒輪。如果要將旋轉運動傳遞到垂直於齒輪的軸上，可以使用傘齒輪（在本套組的直升機模型將會使用到兩個傘齒輪）。

也可以依次排列多個齒輪，將慢速旋轉運動轉換為一個或多個非常快速的旋轉運動 - 如製作手動攪拌機型號時所看到的那樣。

>>> 自行車通常具有鏈條傳動裝置，其中各種尺寸的齒輪通過鏈條連接。

在許多機器和設備內可以找到齒輪系傳動機構。例如，在機械鐘錶中，你可能會在博物館中看到這種類型的鐘錶，通過彈簧或重物推動齒輪之間運動可以傳遞到鐘錶的指針上。

由於齒輪比不同，指針分為可以快速移動的秒針、慢速的分針，以及更慢的時針。

這意味著你通常可以在多個「齒輪」中進行選擇，也就是說，你可以在各種不同的齒輪比之間切換。

這具有明顯的優勢，因為齒輪系不僅傳遞轉速，而且傳遞力量。騎自行車時，保持在同一速度踩踏，最能省力。如果你想要在平坦地形或下坡騎行時，可以在後部切換到高速檔。這將曲柄連接到後輪上的較小的齒輪。來自踏板的力量轉化為更大的驅動力，使得自行車更快地前進。

如果你騎車上山，可以切換到後排大齒輪和前排小齒輪。這使你可以在踏板上施加更小的力，並以更快的速度轉動它們，但後輪的轉動量會更大。

OVERVIEW 概述

Rescue Helicopter
救援直升機

Hand Mixer
手動攪拌器

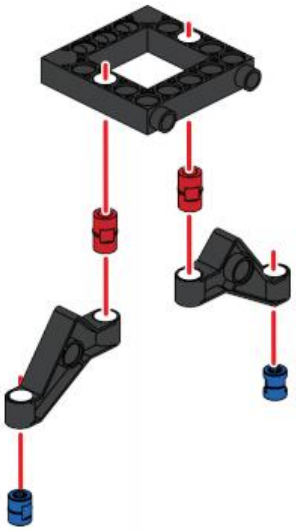
Spinner Toy
陀螺發射儀

Aircraft Launcher
飛機發射器

Flying Scooters
天女散花

Model 模型 1 Rescue Helicopter 救援直升機

1 ×2



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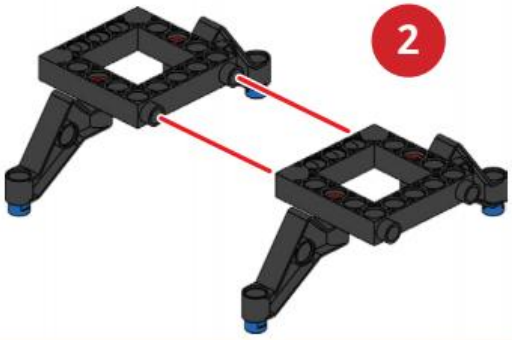

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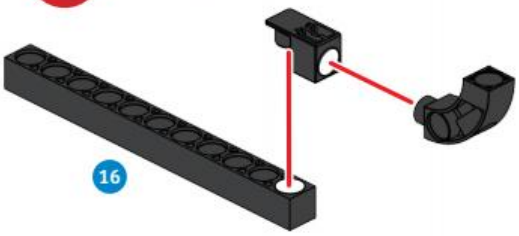

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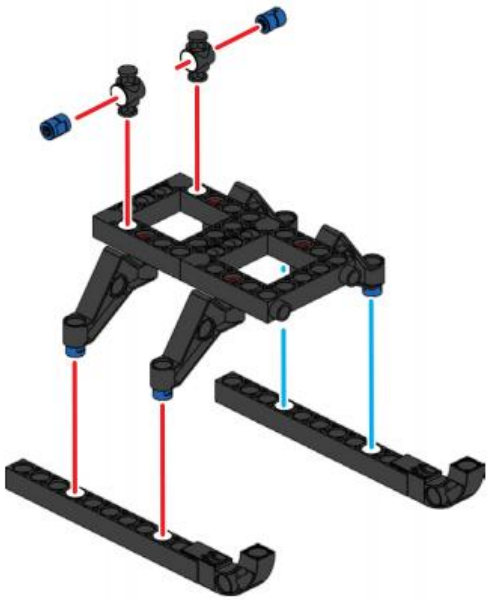

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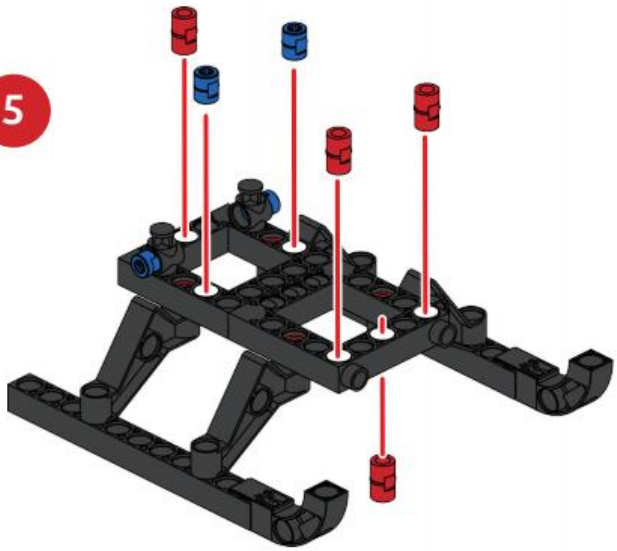

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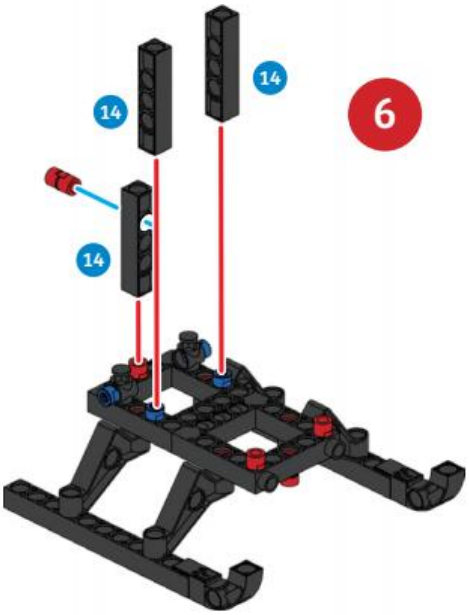

Rescue Helicopter 救援直升機 Model 模型 1

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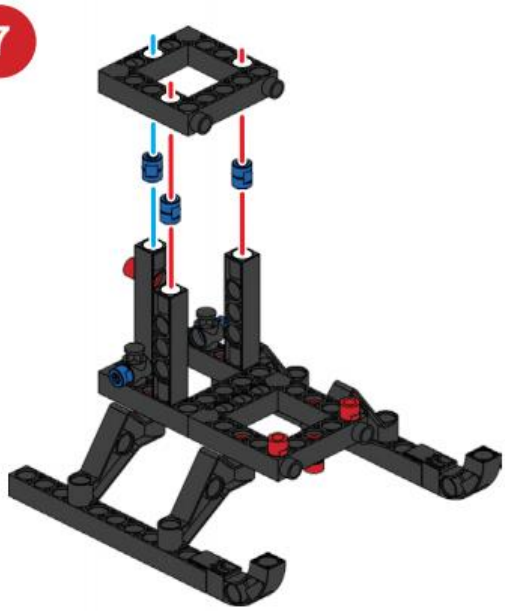

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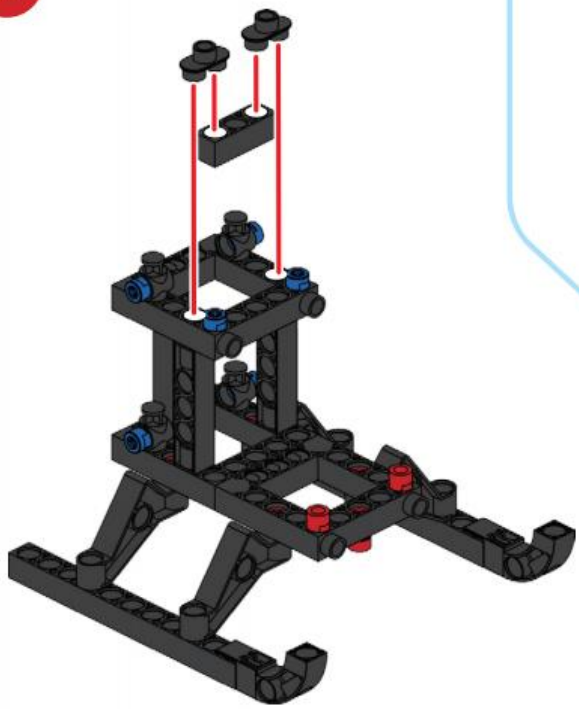

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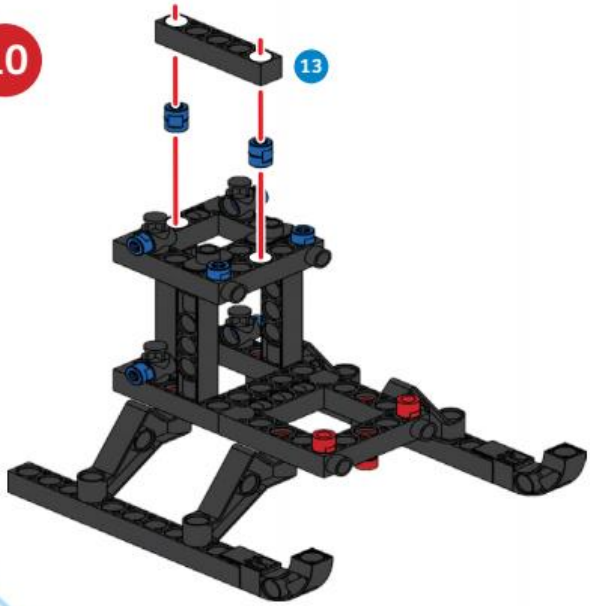

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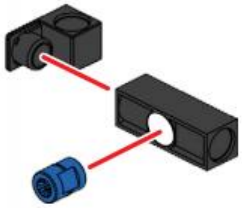

Model 模型 1 Rescue Helicopter 救援直升機

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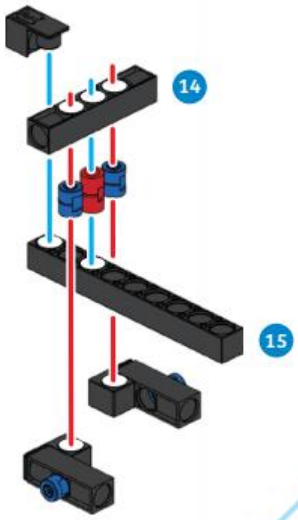

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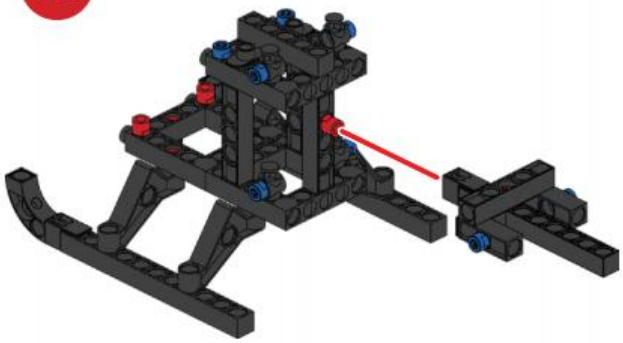

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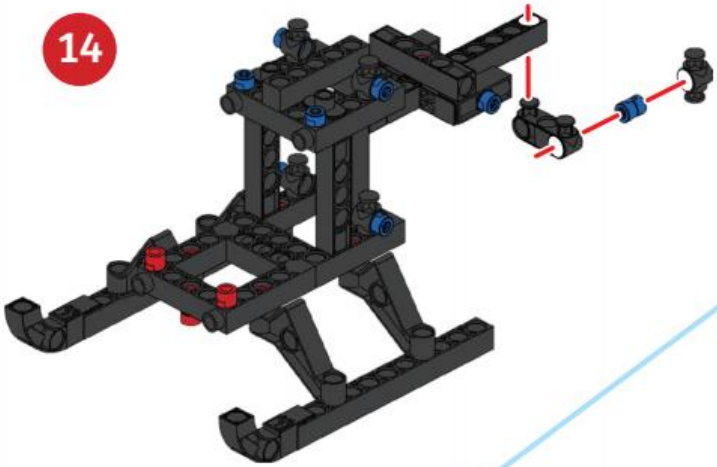

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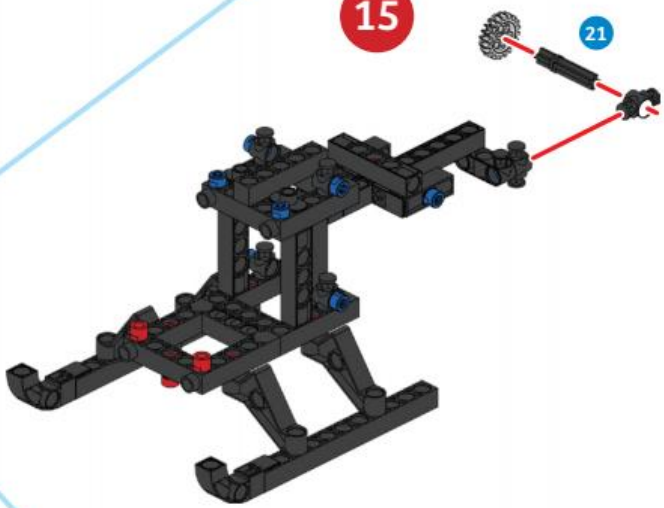

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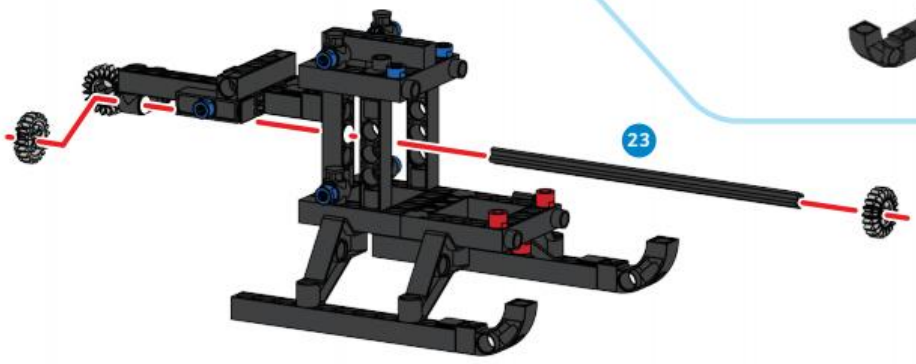

Rescue Helicopter 救援直升機 Model 模型 1

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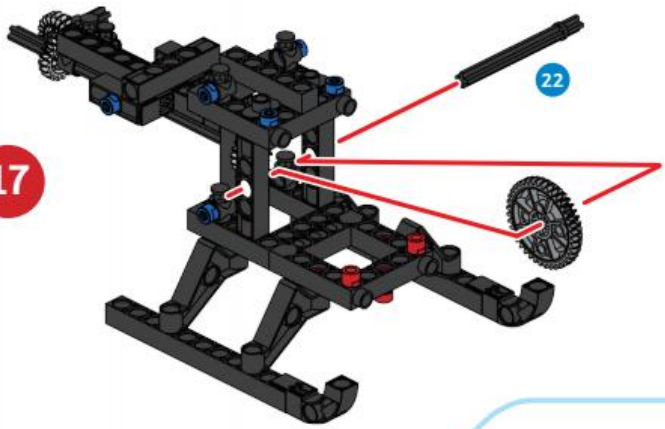

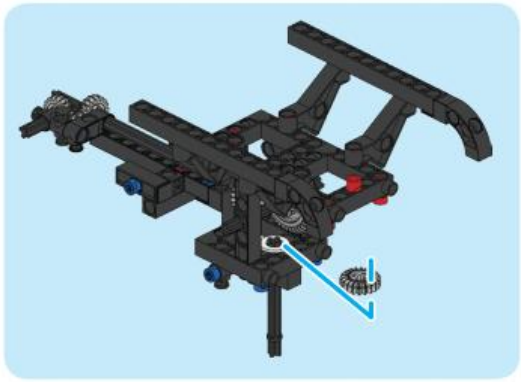

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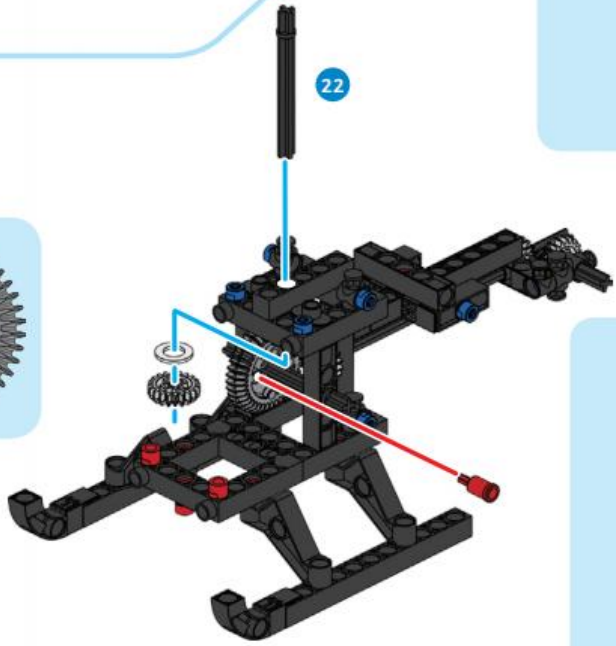

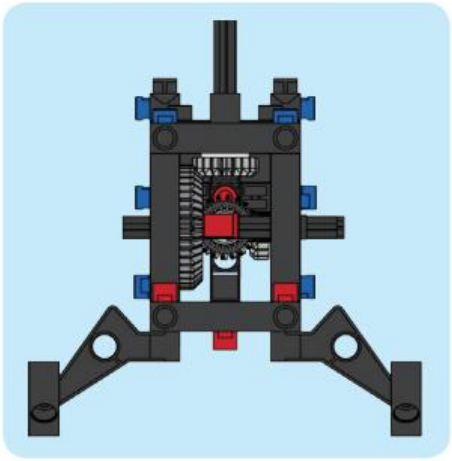

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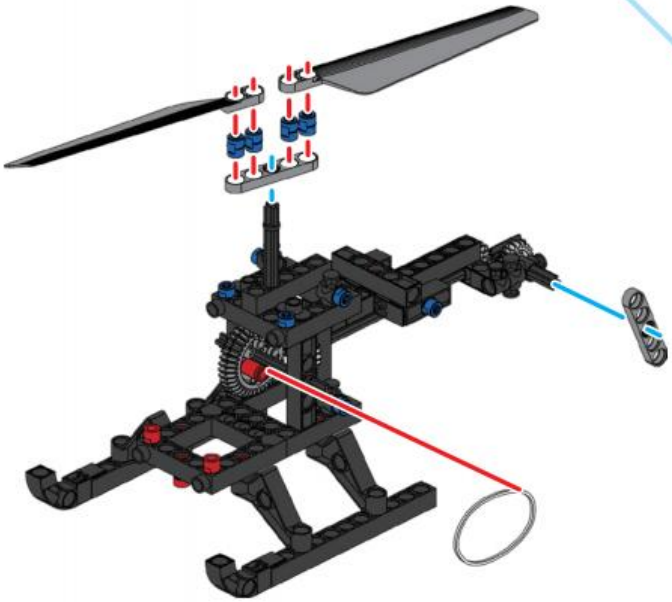

Model 模型 1 Rescue Helicopter 救援直升機

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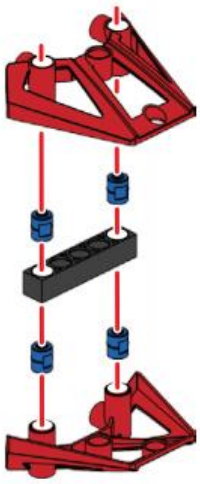

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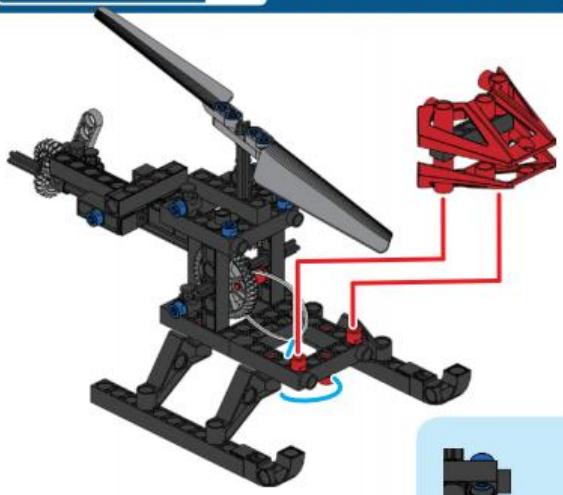

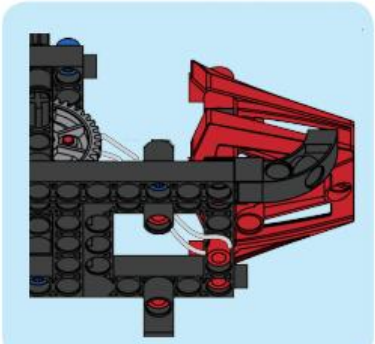

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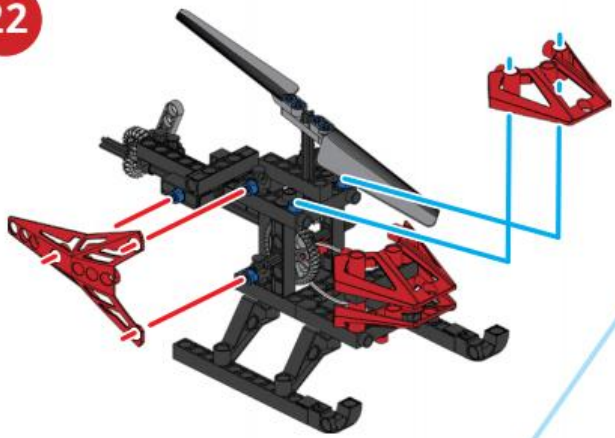

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24

Done!

完成！

Spinner Toy 陀螺發射儀 Model 模型 2

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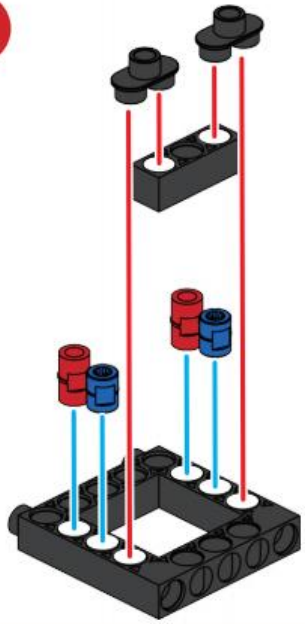

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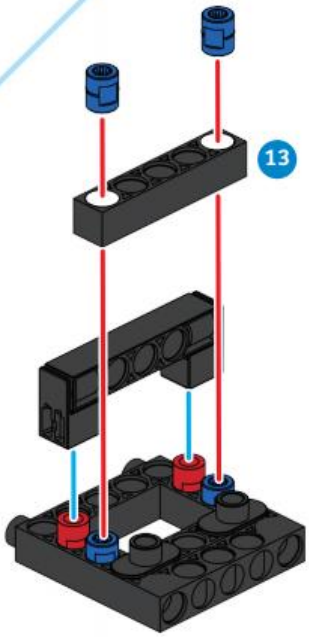

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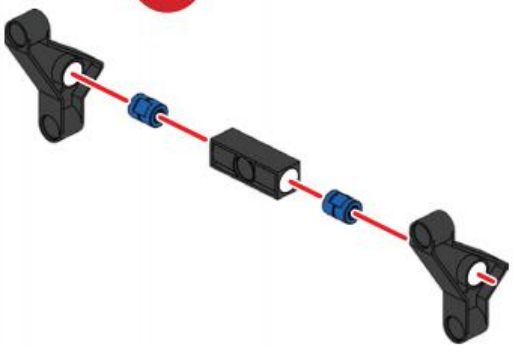

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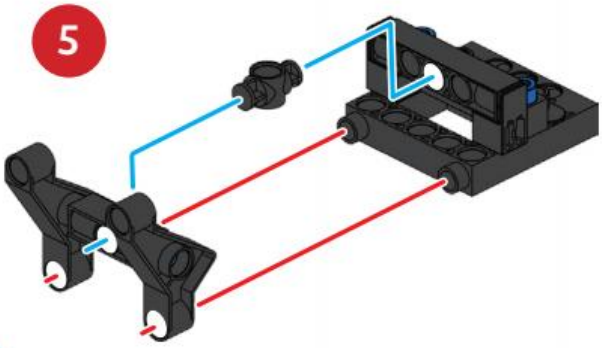

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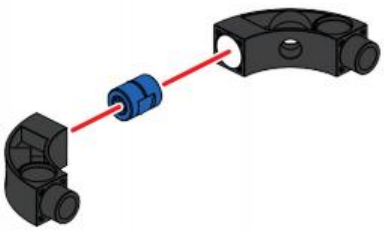

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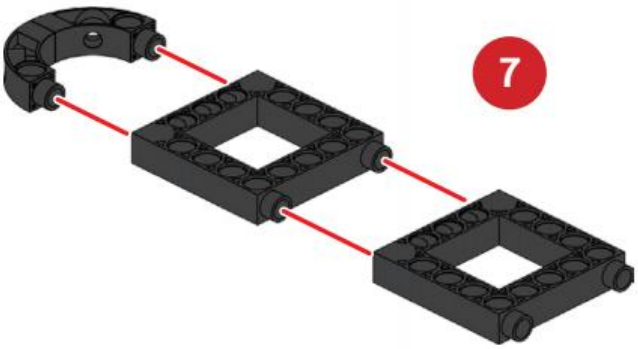

Model 模型 2 Spinner Toy 陀螺發射儀

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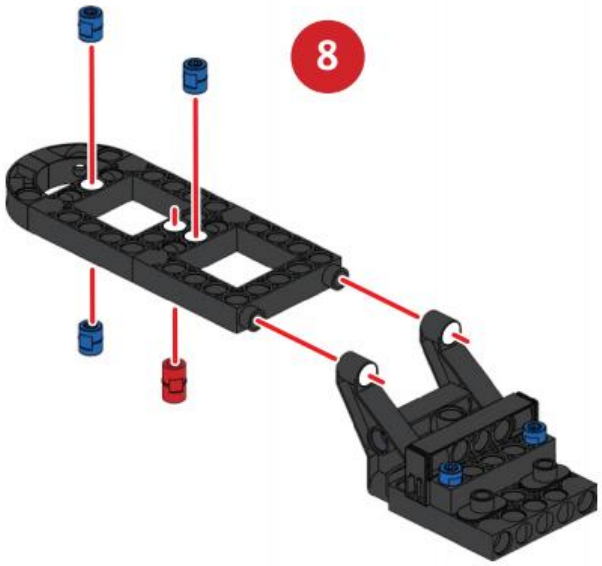

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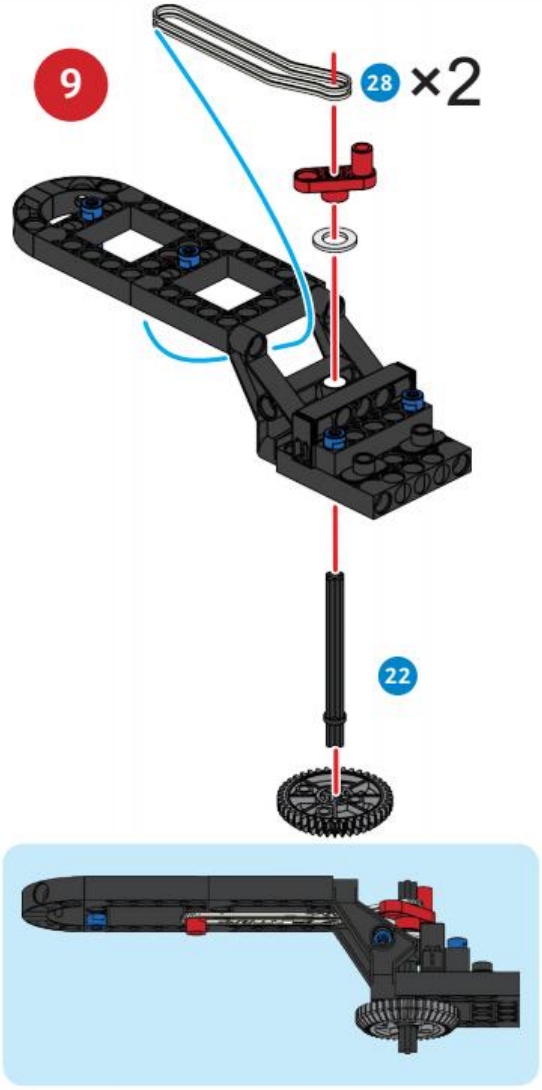

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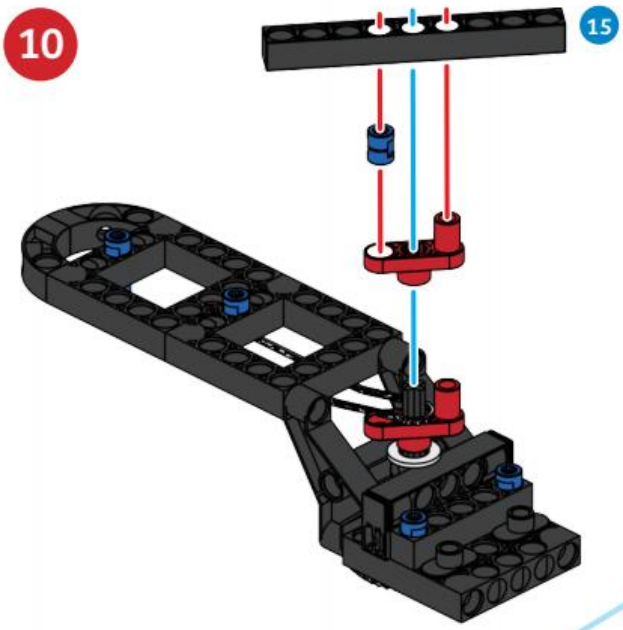

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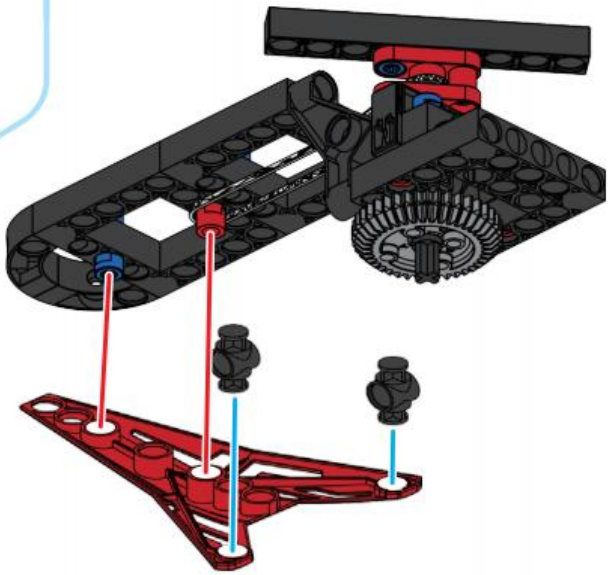
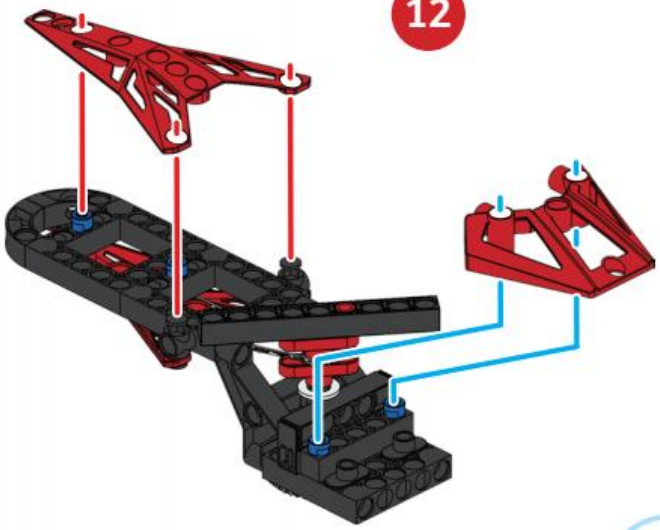


Spinner Toy 陀螺發射儀 Model 模型 2

12



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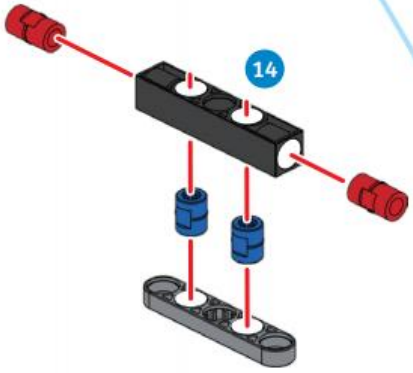

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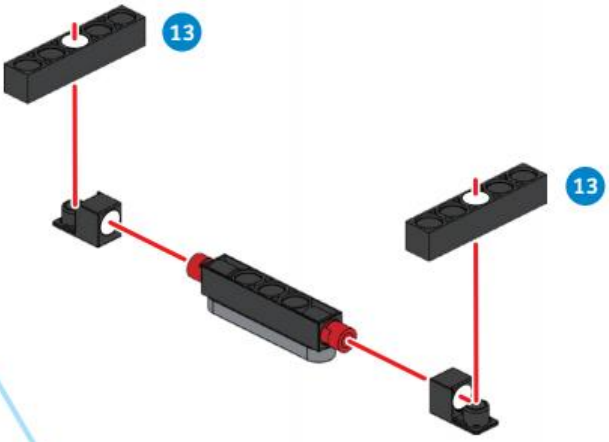

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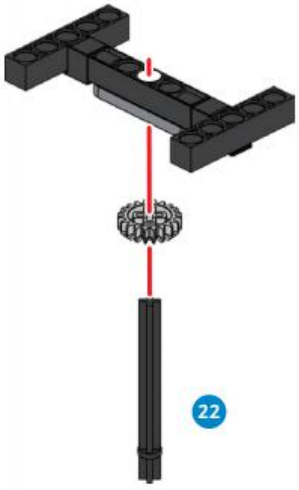

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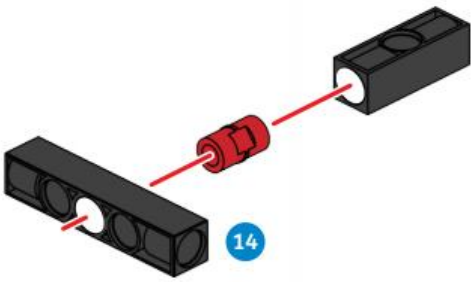

Model 模型 2 Spinner Toy 陀螺發射儀

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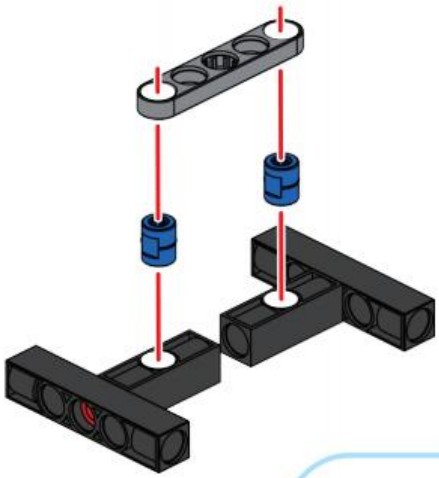

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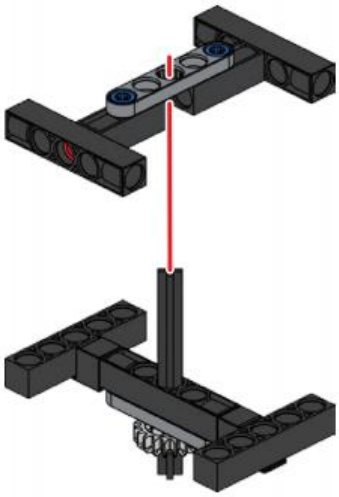

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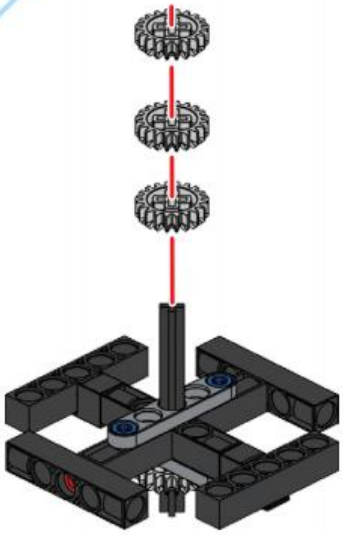

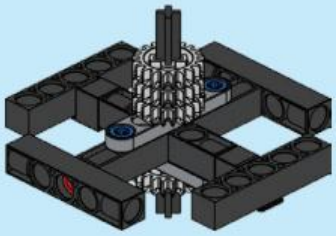

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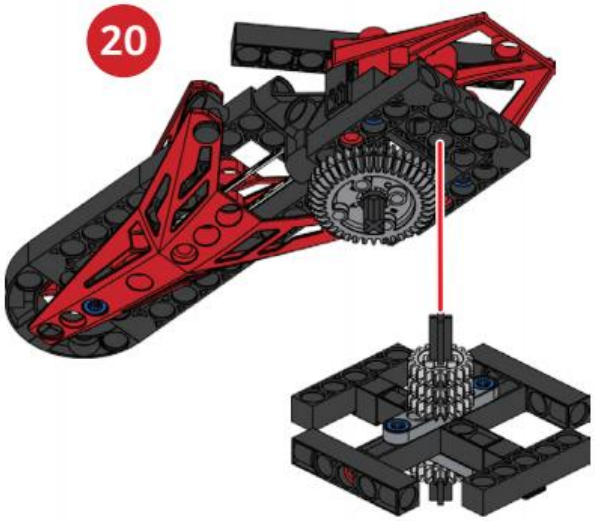


21

Done!

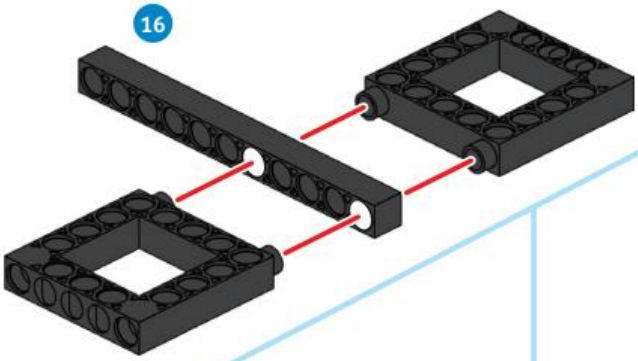
完成！

Spin the top and then let go!

旋轉頂部，然後放開！

Hand Mixer 手動攪拌器 Model 模型 3

1



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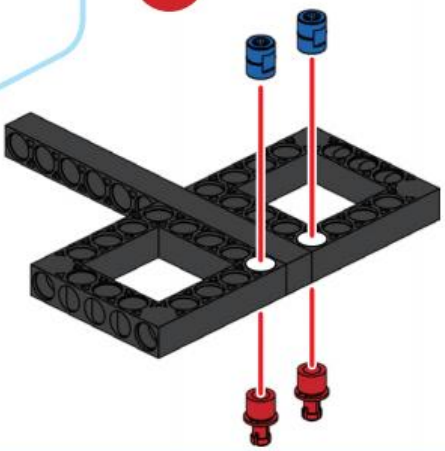

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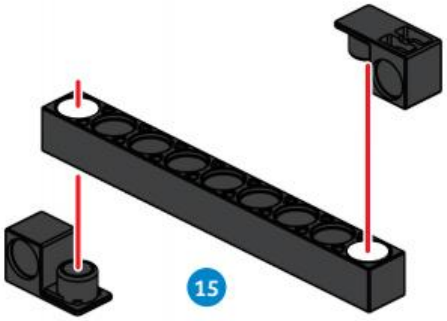

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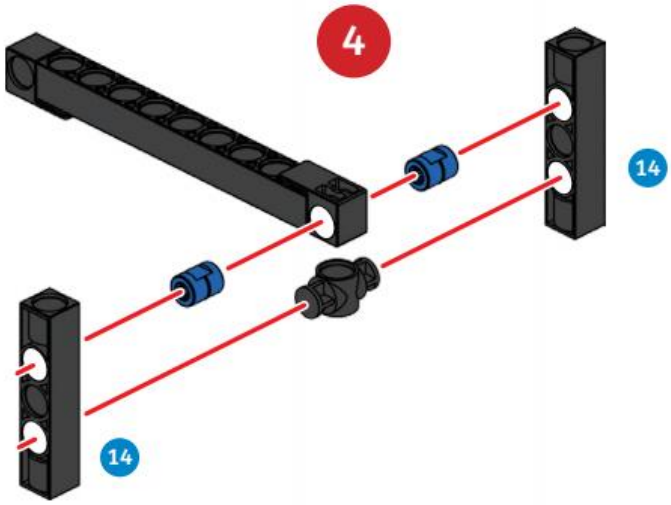

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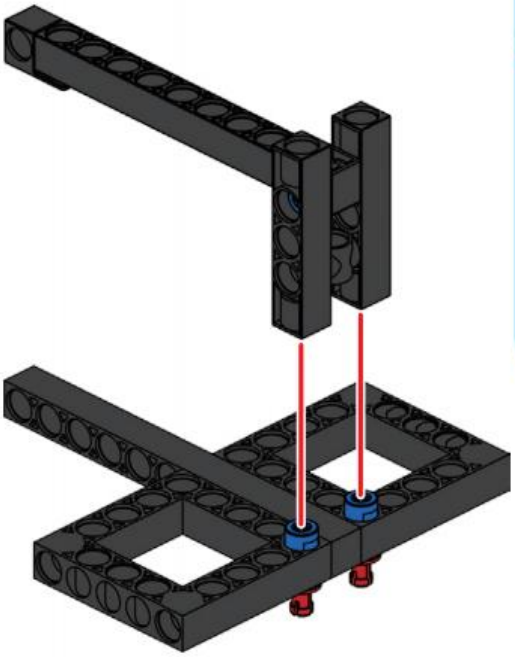

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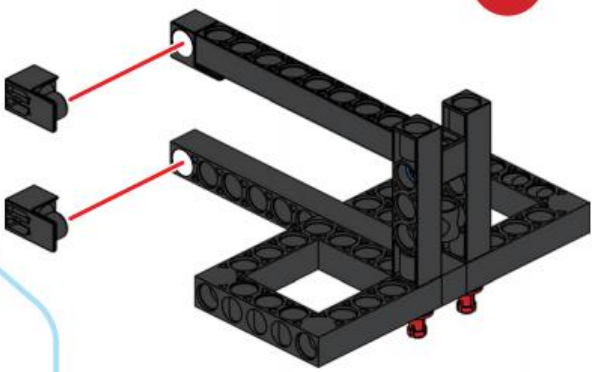

Model 模型 3 Hand Mixer 手動攪拌器

7

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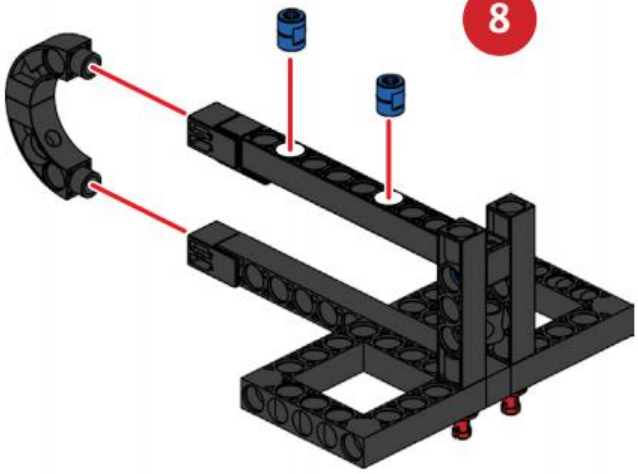

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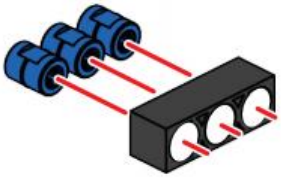

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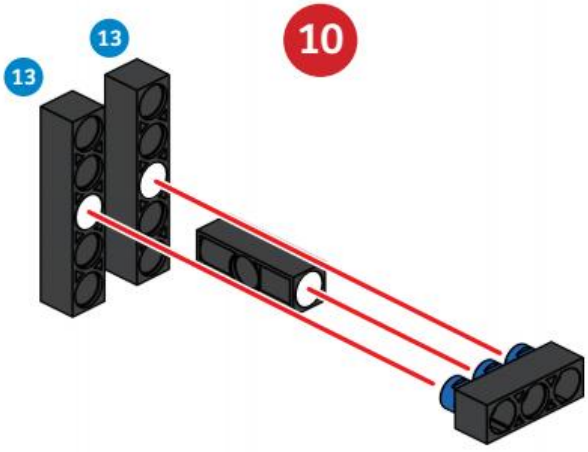

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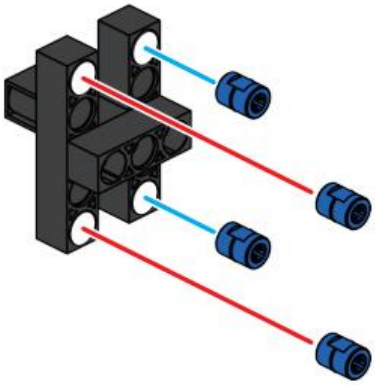

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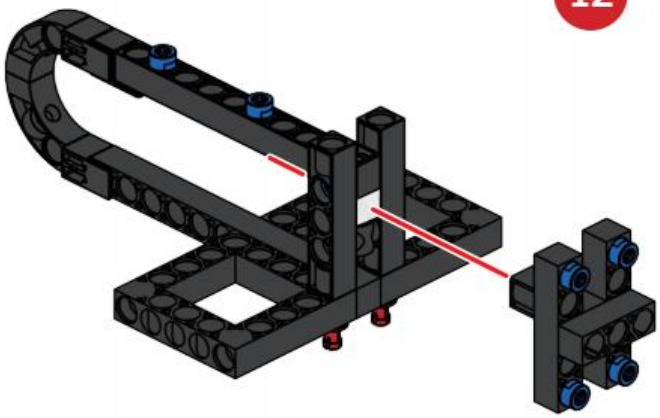

Hand Mixer 手動攪拌器 Model 模型 3

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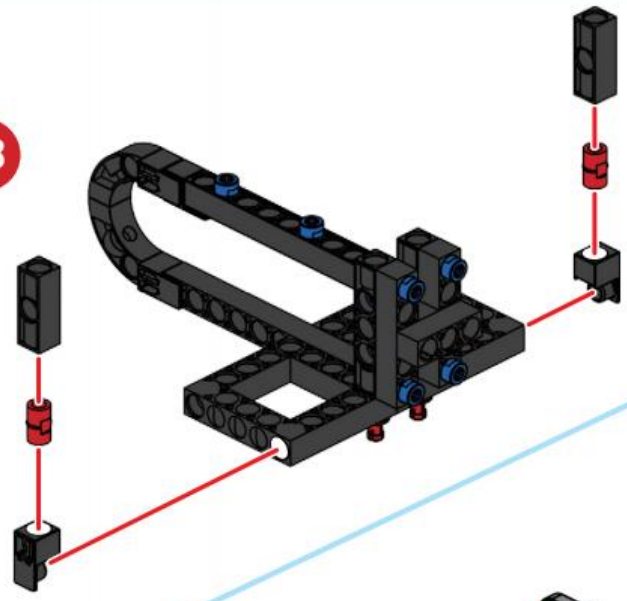

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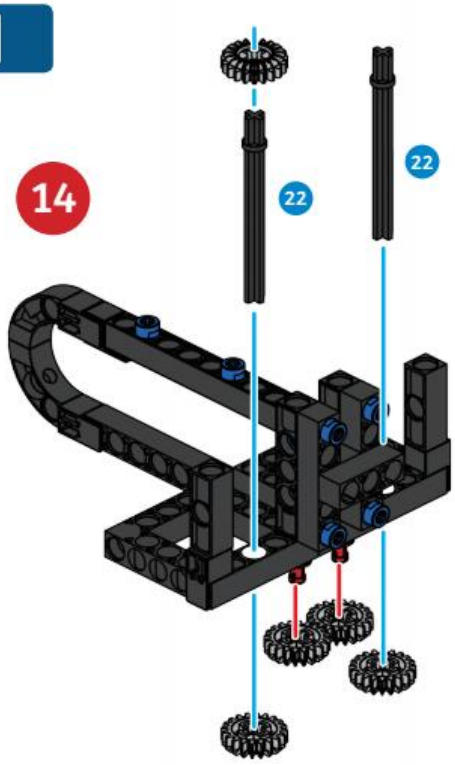

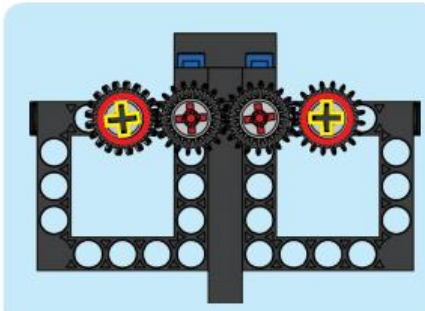

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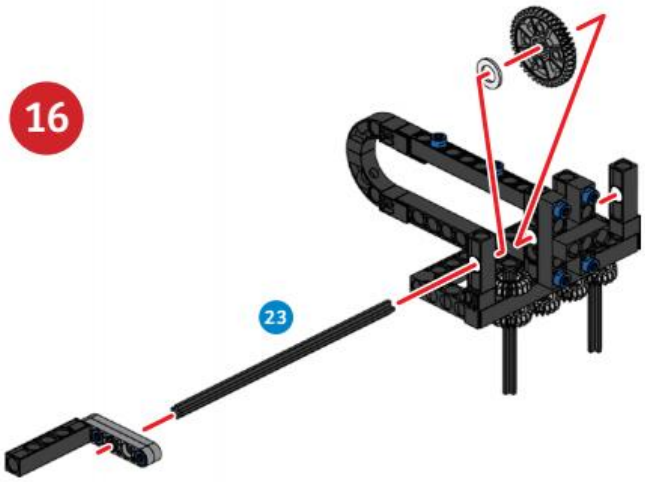

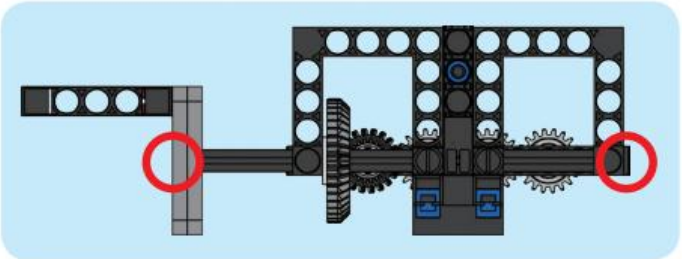

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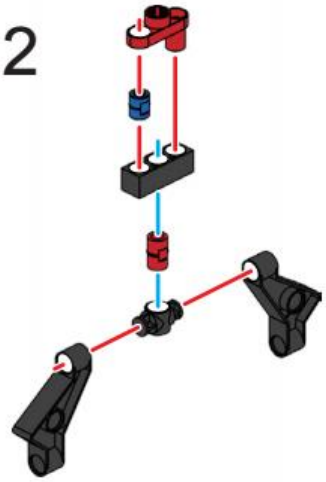
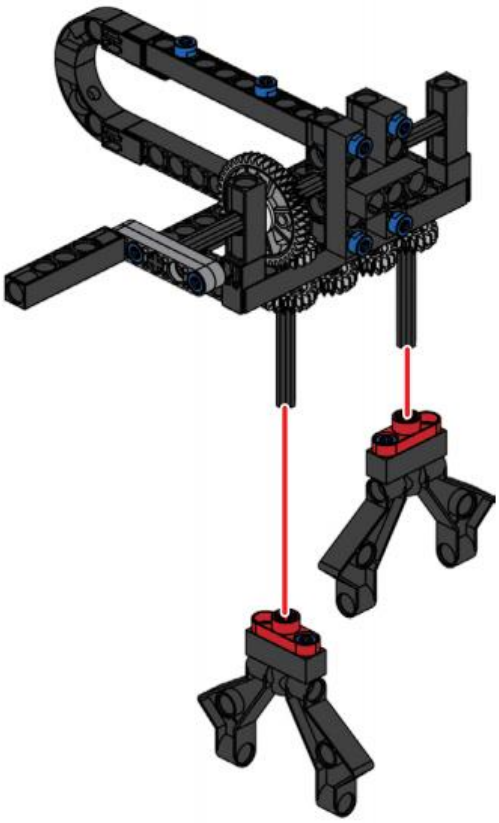
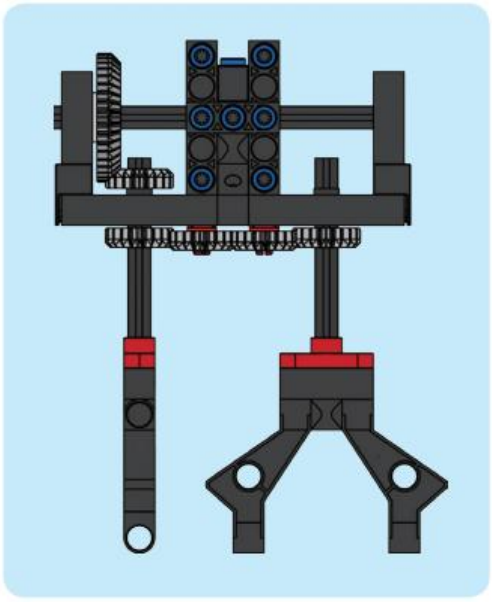


Model 模型 3 Hand Mixer 手動攪拌器

18





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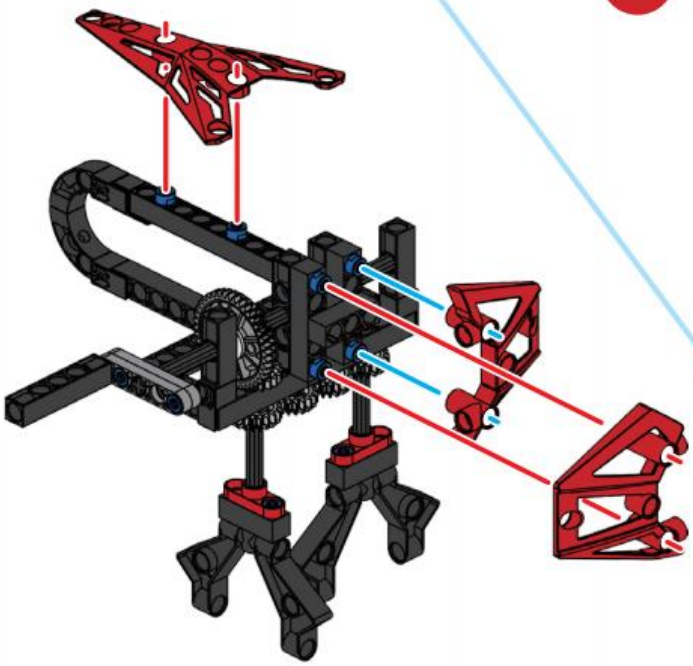

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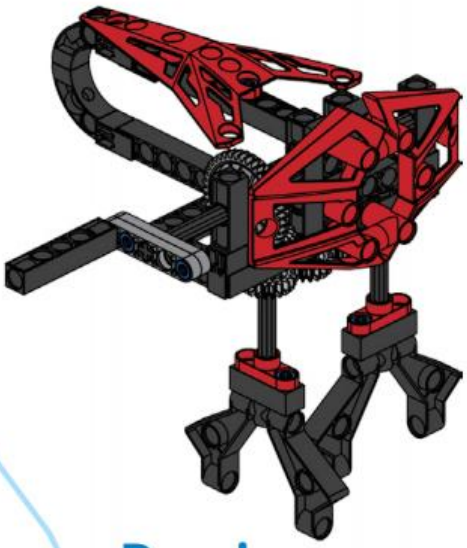

Done!

完成！

Aircraft Launcher 飛機發射器 Model 模型 4

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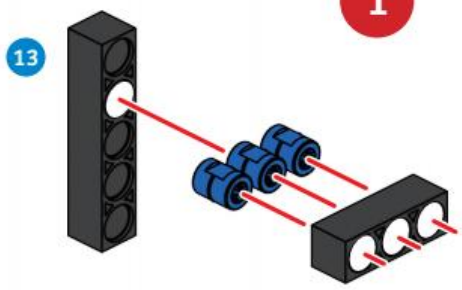

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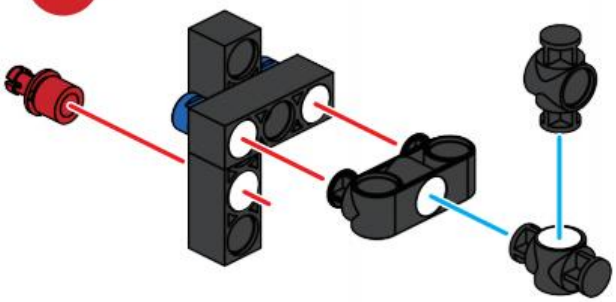

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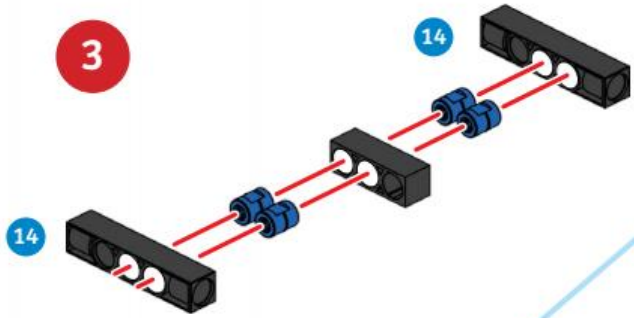

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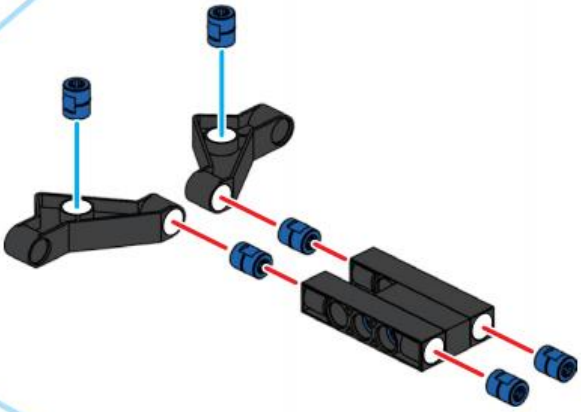

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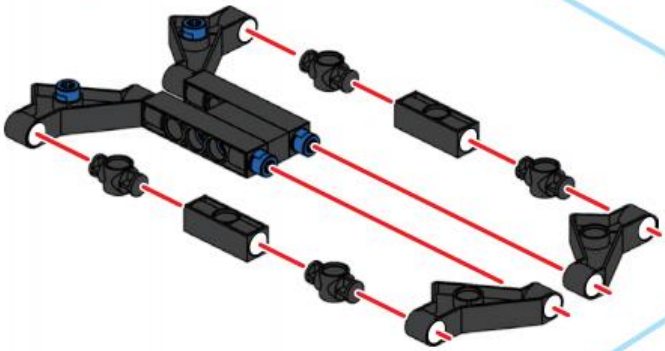

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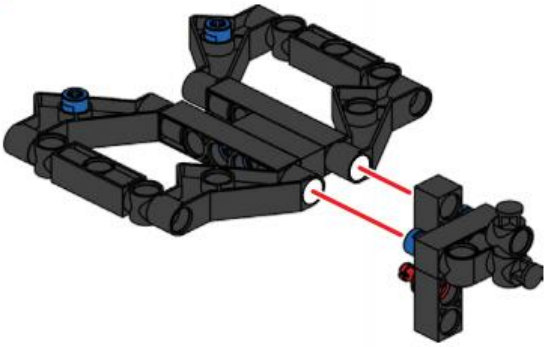
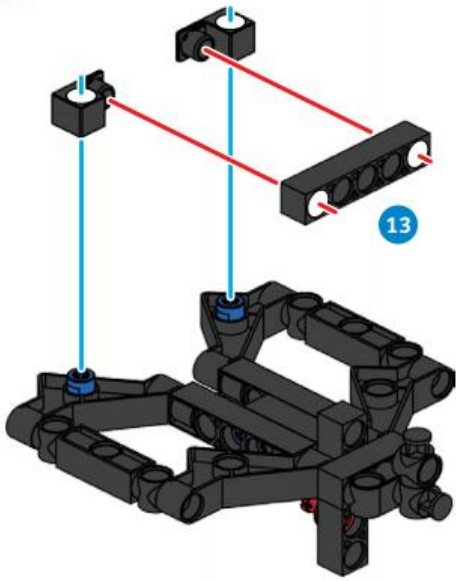


Model 模型 4 Aircraft Launcher 飛機發射器

7



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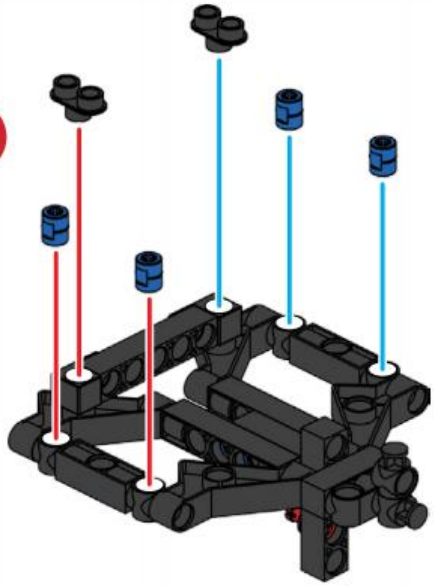

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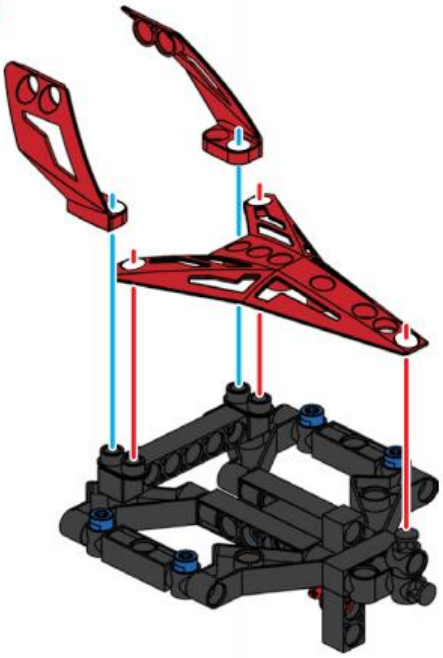

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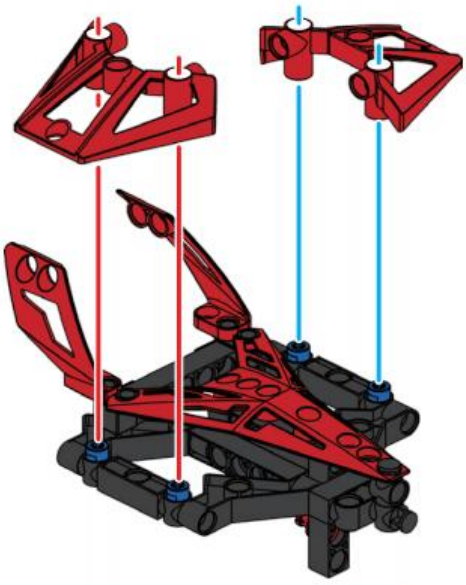
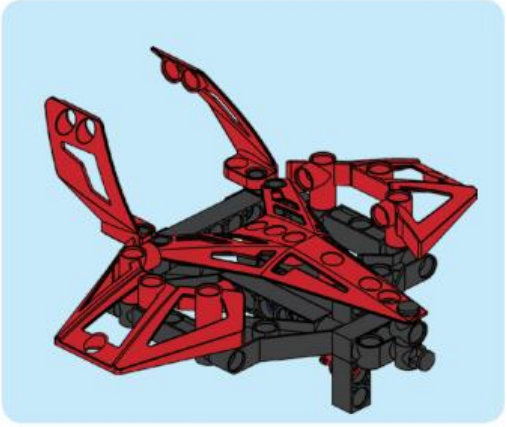
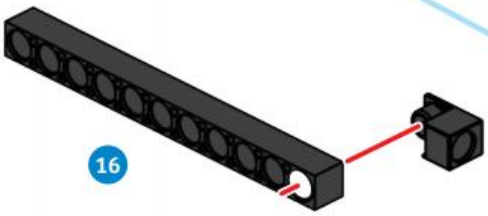




Aircraft Launcher 飛機發射器 Model 模型 4

11



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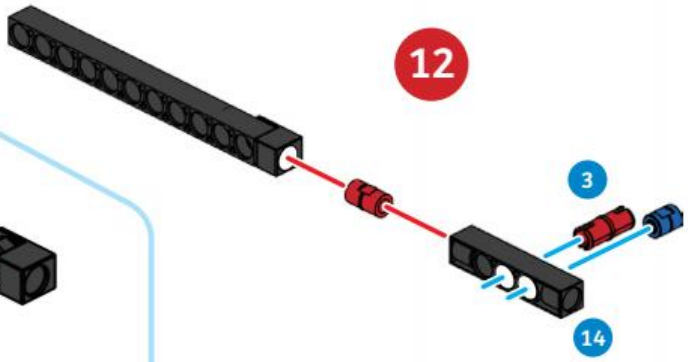

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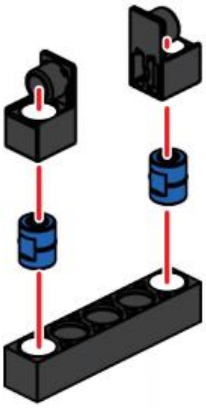

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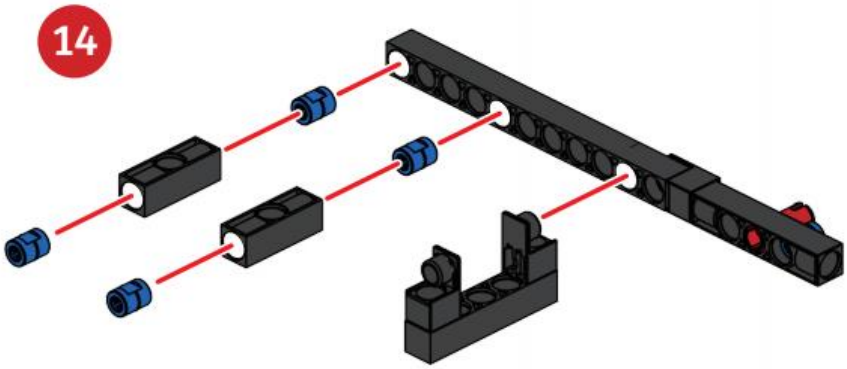

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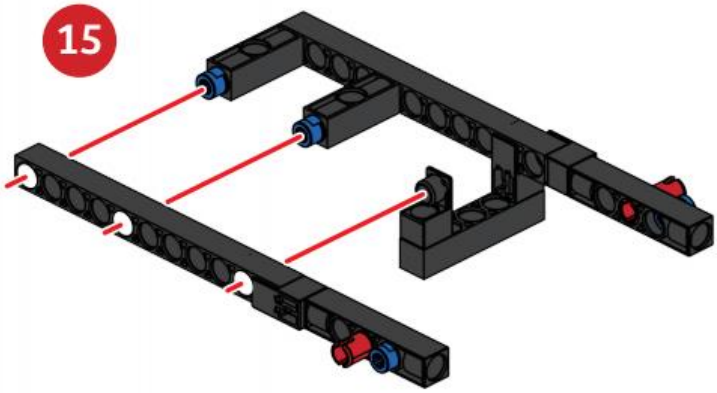

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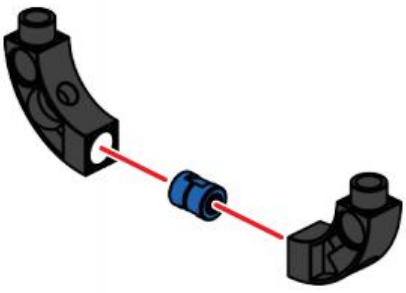

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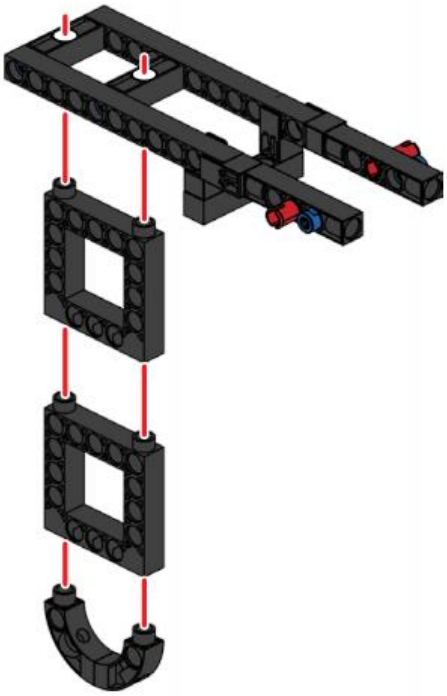
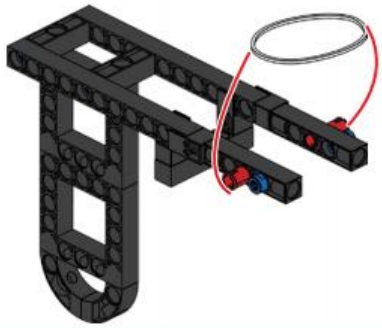
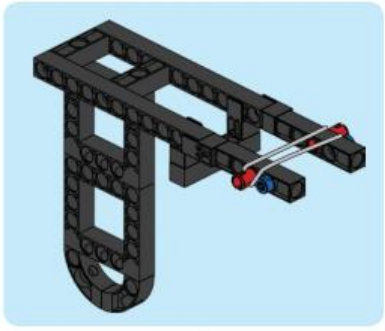


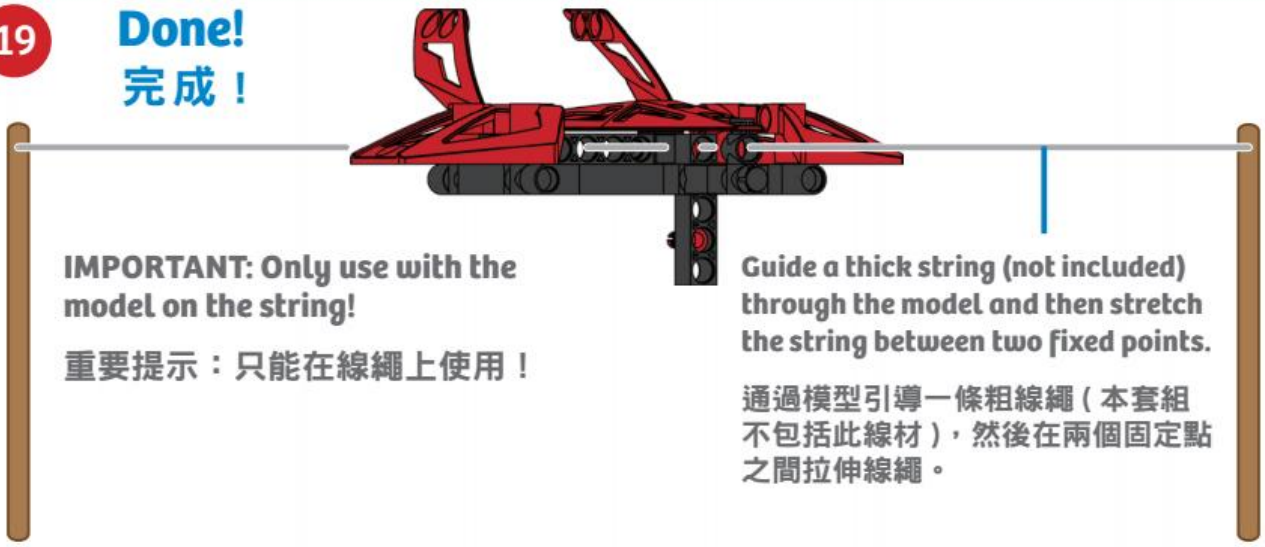
Model 模型 4 Aircraft Launcher 飛機發射器

18





19 **Done!**
完成！



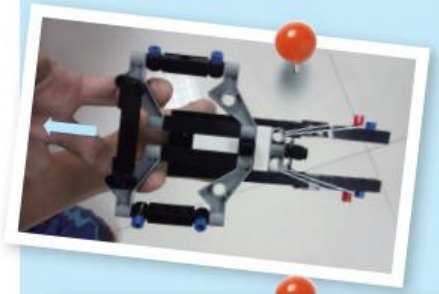
IMPORTANT: Only use with the model on the string!

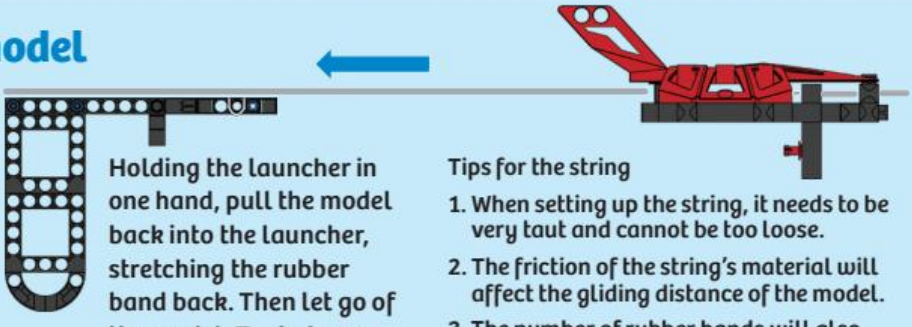
重要提示：只能在線繩上使用！

Guide a thick string (not included) through the model and then stretch the string between two fixed points.

通過模型引導一條粗線繩（本套組不包括此線材），然後在兩個固定點之間拉伸線繩。

How to launch the model
如何啟動模型





Holding the launcher in one hand, pull the model back into the launcher, stretching the rubber band back. Then let go of the model. Try to keep everything lined up on the same plane such that the string is level and straight.

一手拿著發射器，將模型拉回發射器中，將橡皮筋往後拉。 然後放開模型。盡量讓所有的東西排列在同一個平面上，以保證線繩平直。

Tips for the string

1. **When setting up the string, it needs to be very taut and cannot be too loose.**
2. **The friction of the string's material will affect the gliding distance of the model.**
3. **The number of rubber bands will also affect the gliding distance of the model.**
4. **If you have wax at home, you can apply some on the rope to reduce the friction from the rope.**

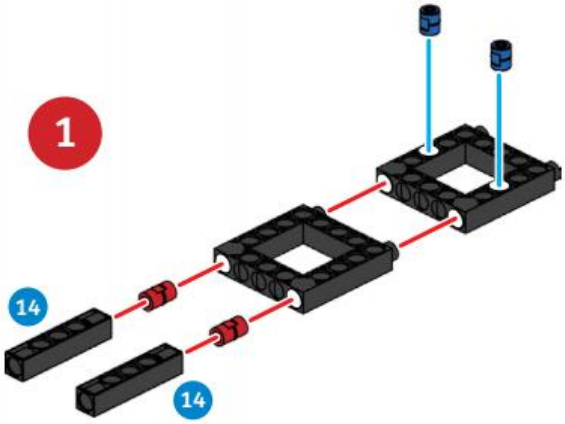
線繩小技巧

1. 設置線繩時，需拉緊線繩，不能太鬆。
2. 線繩材料的摩擦力會影響模型的滑動距離。
3. 橡皮筋的數量也會影響模型的滑動距離。
4. 如果家裡有蠟，可以在繩上塗一些蠟以減少繩子的摩擦力。

Model Operation Video
模型操作影片

Flying Scooters 天女散花 Model 模型 5

1



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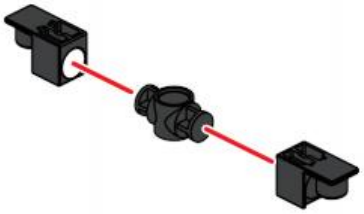

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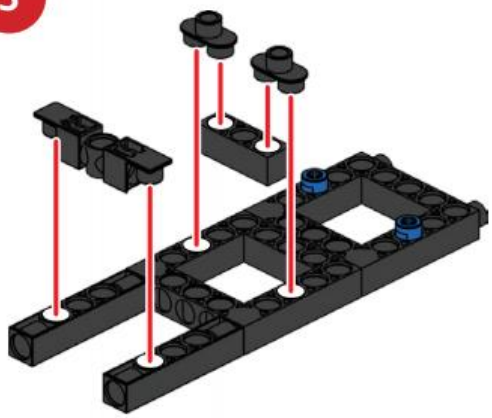

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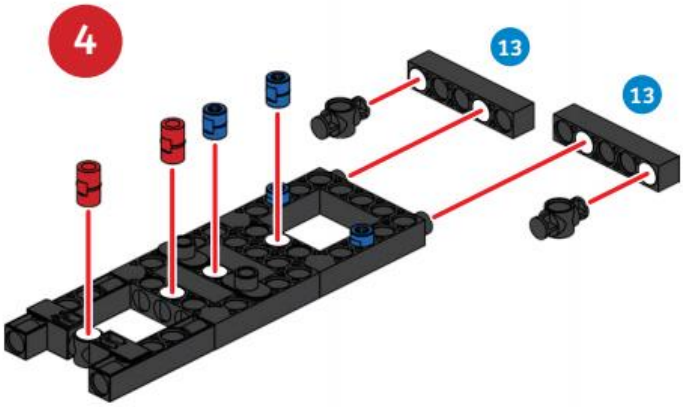

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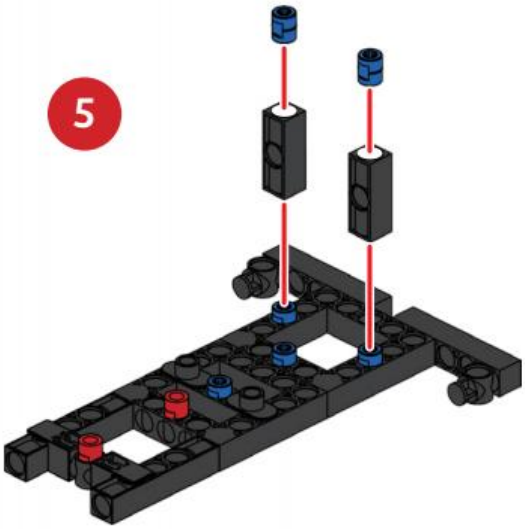

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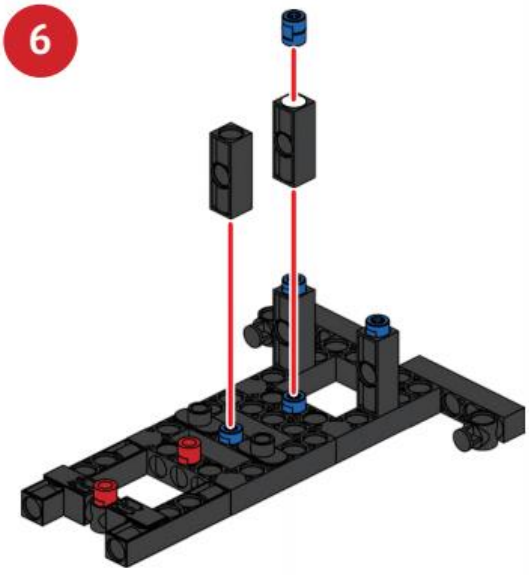
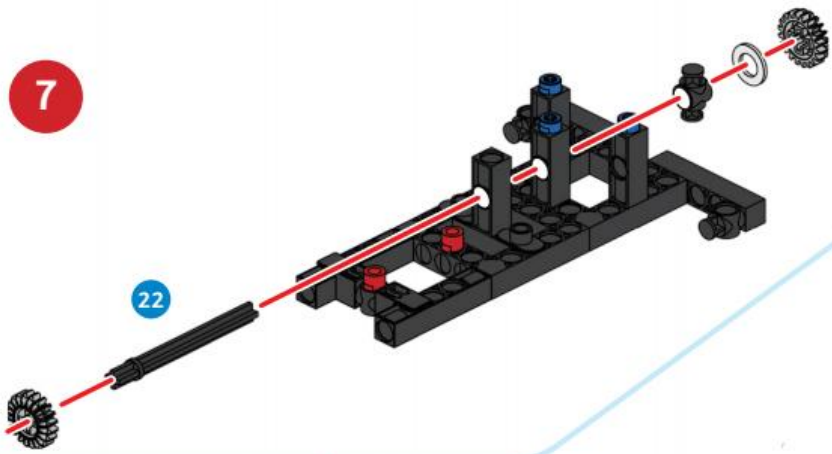


Model 模型 5 Flying Scooters 天女散花

7



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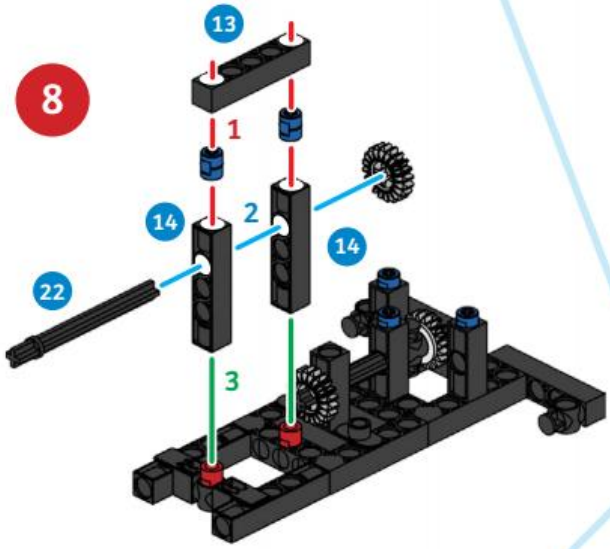

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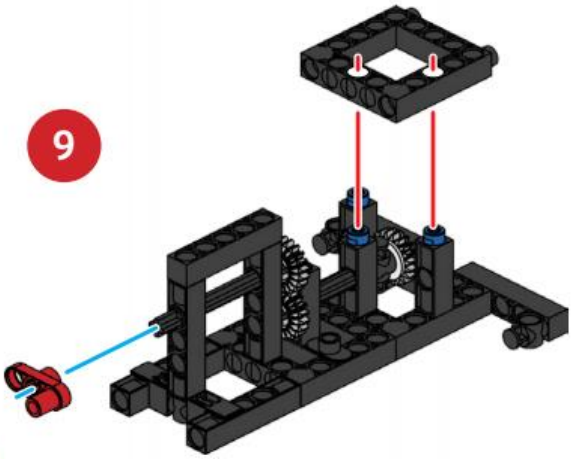

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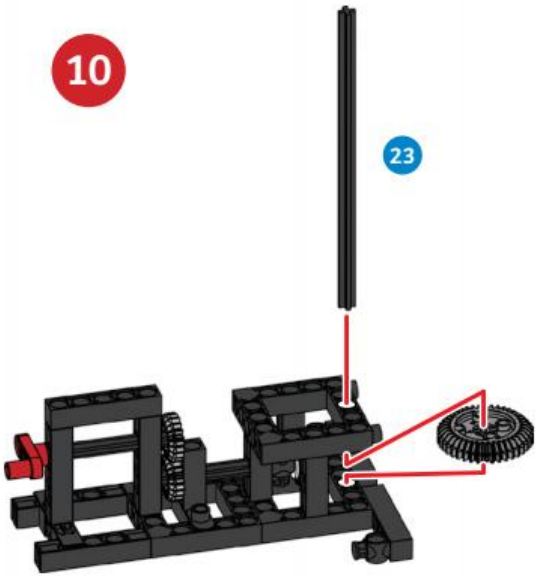

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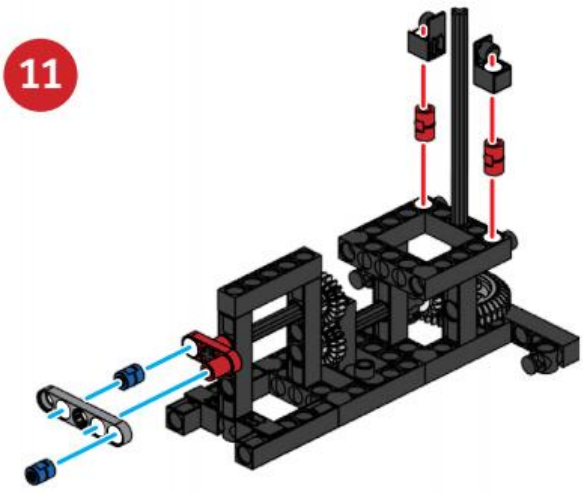
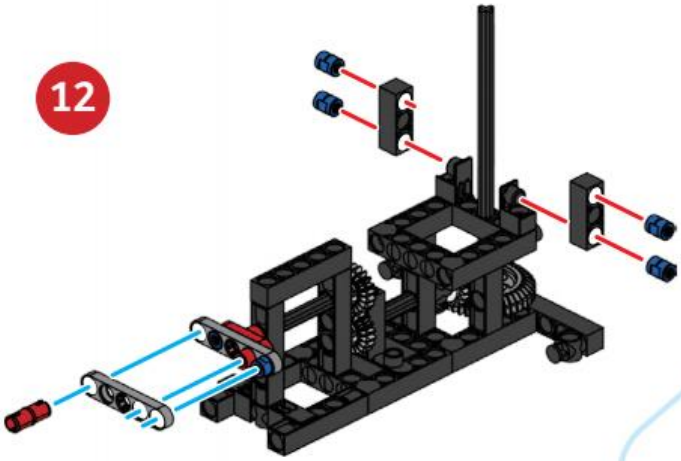


Flying Scooters 天女散花 Model 模型 5

12



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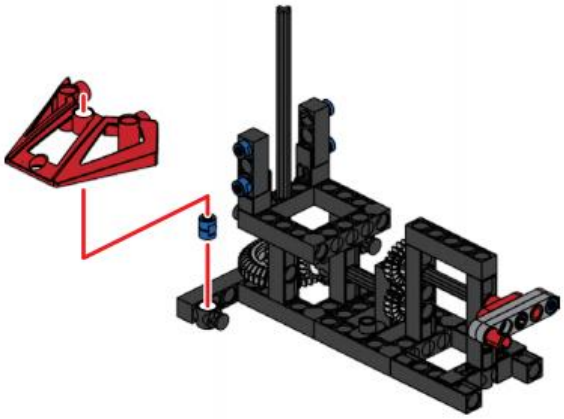

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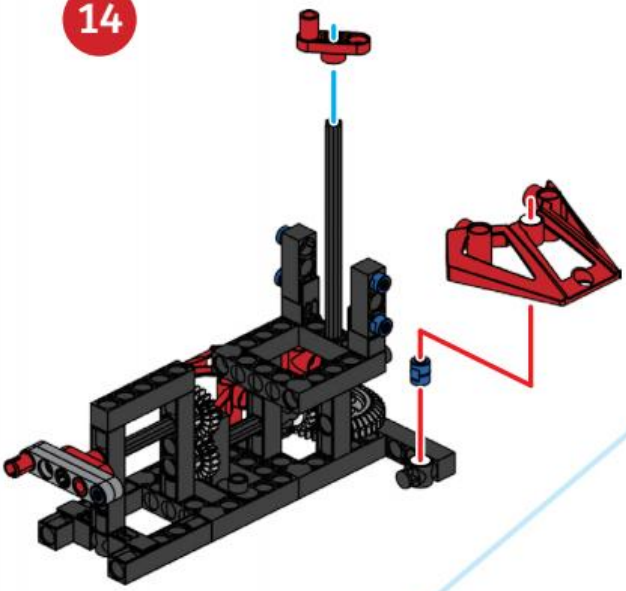

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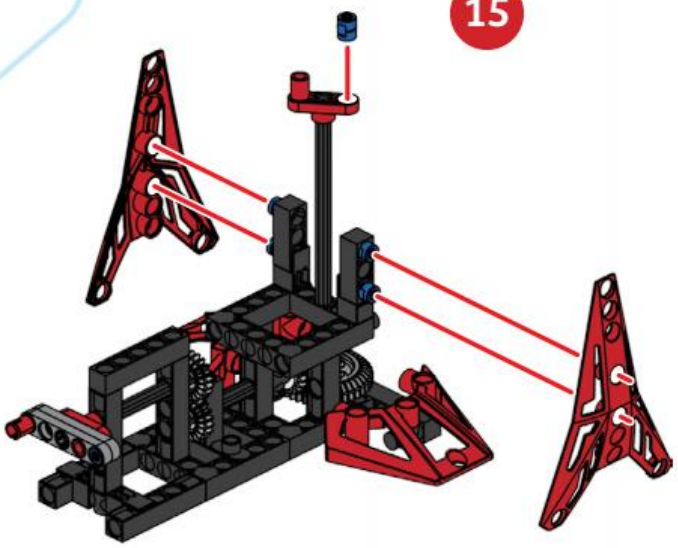
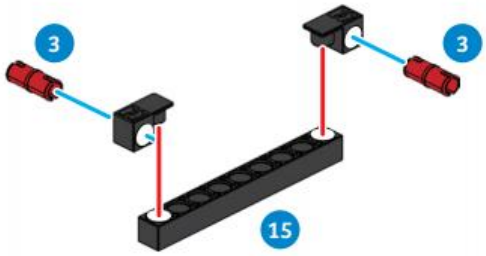


Model 模型 5 Flying Scooters 天女散花

16



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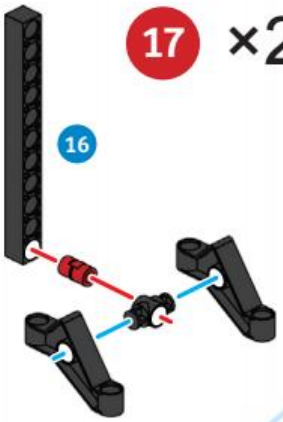

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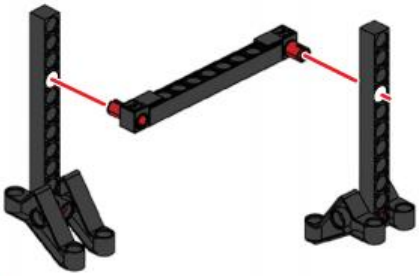

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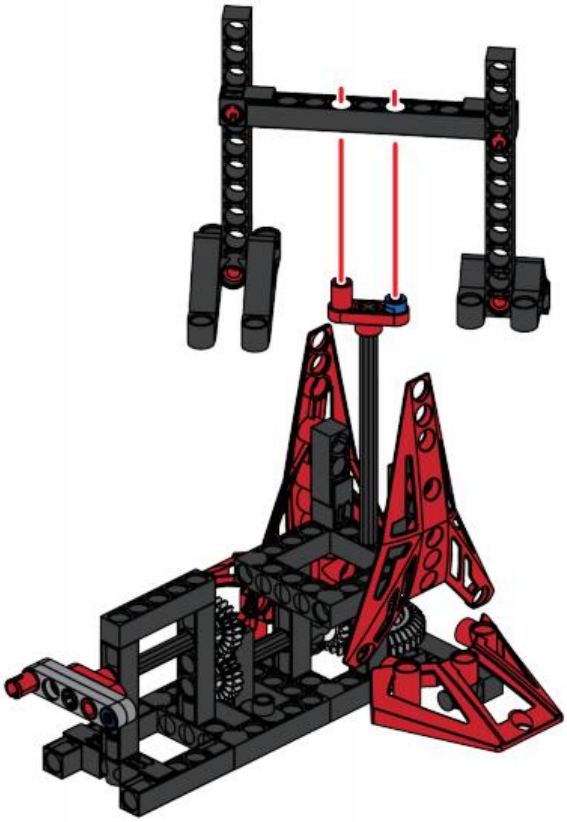


20

Done!

完成！

GOOD TO KNOW 新知趣聞

AMAZING FACTS!

For a long time, gear systems were considered to be an exclusively human invention. So when a group of British biologists discovered an insect with its very own gear system some years ago, their finding was all the more astonishing. The insect in question was the larva of the Issid Planthopper (scientific name Issus coleoptratus), a tiny creature just a few millimeters in size.

Of course, they can only take off cleanly if both hind legs move at the exact same time and push off with the exact same force.

››› These insects tend to get around by jumping: if disturbed, they use their powerful hind legs to send themselves shooting upward.

Otherwise, the little creature will find itself hurtling off into a spiral, possibly lurching and making for easy prey. This synchronized movement is ensured by a minuscule gear system, consisting of two interlocking structures attached to the insect's legs.

This means that the real inventor of the gear wheel is in fact Mother Nature, and she was using it millions of years before humans even existed!

GOOD TO KNOW 新知趣聞

驚人的事實！

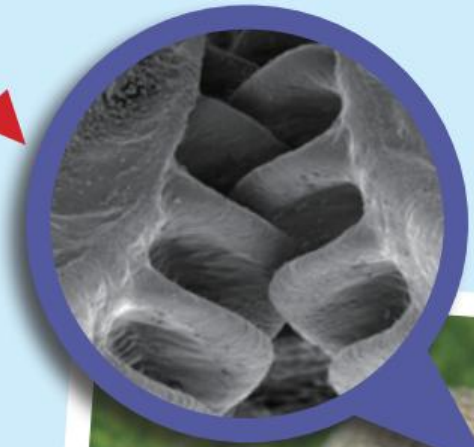
多年以來，齒輪被視為是一種由人類發明且只有人類才懂得運用的工具。直至近年，當英國生物學家們發現一種自己擁有齒輪系統的昆蟲存在時，他們非常的驚訝。這種昆蟲是伊蘇斯飛虱（Issid Planthopper，學名 Issus coleoptratus）的幼蟲，它是一種幾公釐大小的小生物。

當然，如果牠能將兩隻後腿同時施力並以完全相同的力量推動，它們就能簡單而直接地飛起。

>>> 這些昆蟲在感受到威脅時會透過跳躍來閃避危險：每當牠們受到驚嚇時，他們會用強大的後腿將自己以向上彈射的方式躲開。

不過，牠很可能會因為兩腿的施力不均，導致自己以螺旋狀飛行，無法穩定前進且更容易被獵食者捕食。所以為了確保兩腿同步運動就必須通過一個小型的齒輪機構，該齒輪機構由兩個互鎖結構組成，連接到昆蟲的腿上。

這代表大地之母才是齒輪真正的發明者，並且在人類出現之前，祂已經使用齒輪長達數百萬年之久！



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