



# ENGINEERING MAKERSPACE

## KINETIC MACHINES

### 創客工程 動能彈力組

# EXPERIMENTS



# 7444

108 PCS

6+

STEAM

LEARN ABOUT FORCE,  
MOTION, AND ENERGY  
了解力量、運動和能量



5 MODELS  
TO BUILD





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On page 7, you can see all of 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 about kinetic energy on page 27

在第28頁上，介紹動能的基礎概念。

## 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.

**Warning!** Do not aim at eyes or face. Do not aim the projectiles toward other people or animals. Make sure people and animals are well out of the potential path of the projectiles.

**Warning!** The catapult model is able to discharge objects other than the suggested projectiles. Do not use with any other objects than the ones suggested (especially not heavy or sharp-pointed ones). There is a risk of injury. For use under adult supervision. Please make sure that the catapult is stored uncharged.

Clear sufficient space before launching the motorcycle. Keep small children or animals away when launching the motorcycle (in order to prevent nearby objects from breaking).

**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.**

**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。

**警告！** 不要瞄準眼睛或臉射擊。不要將射彈瞄準其他人或動物。確保人和動物遠離彈道的可能路徑。

**警告！** 投石機模型能夠彈射本套組射彈以外的其他物體。

不要與其他物體一起使用（特別是過重或尖銳的物體）。有受傷的危險。請在成人監督下使用。請先移除投石機上的所有發射物，再進行投石機的收納。

在發射摩托車之前，請清除路面，確保有足夠的空間。在發射摩托車時，請確保附近沒有小孩或動物（以防止鄰近的物體遭受破壞）。

將實驗材料和組裝模型存放在小孩接觸不到的地方。

本套組內的所有模型僅適用於室內使用。請勿帶入沙坑中使用。

**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。

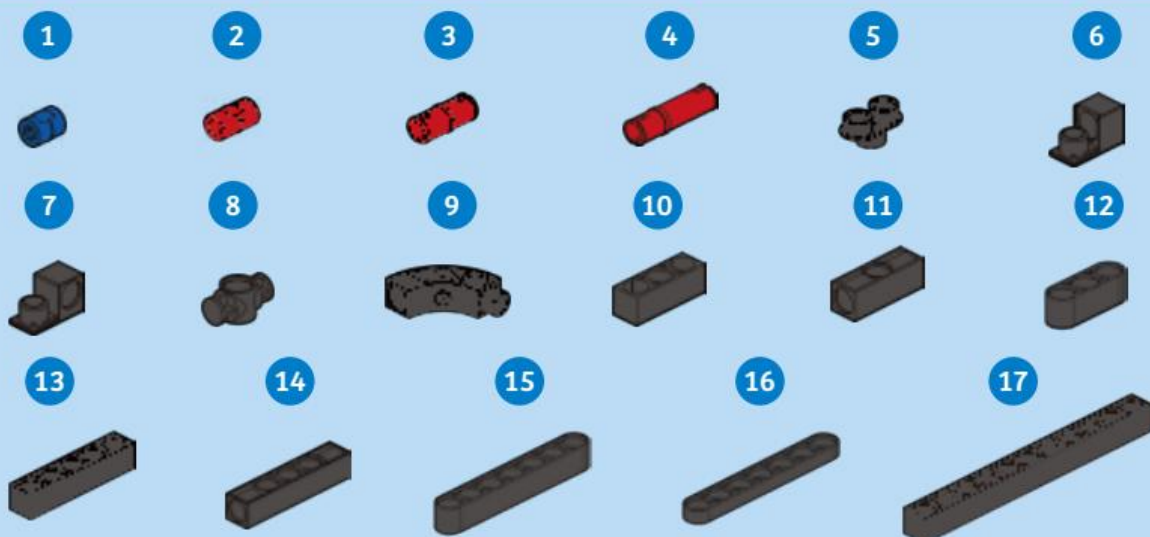
**我們希望您和您的孩子在使用本套組時能獲得樂趣與完成有趣的實驗！**





## 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	ITEM NO. 品號
<input type="radio"/>	1 B-SHORT PEG	B- 短結合鍵	30	7344-W10-C2B
<input type="radio"/>	2 C-LONG PEG	C- 長結合鍵	10	7344-W10-C2B
<input type="radio"/>	3 C-20mm AXLE CONNECTOR	C-20mm 軸扣鍵	4	7413-W10-T1R
<input type="radio"/>	4 C-30mm AXLE CONNECTOR	C-30mm 軸扣鍵	1	7413-W10-U1R
<input type="radio"/>	5 C-TWO-IN-ONE CONVERTER	C- 二合一結合鍵	4	7061-W10-G1D
<input type="radio"/>	6 C-FRONT CONVERTER	C- 單向轉接鍵	2	7061-W10-Y1D
<input type="radio"/>	7 C-LATERAL CONVERTER	C- 雙向轉接鍵	3	7061-W10-X1D
<input type="radio"/>	8 C-1 HOLE CONNECTOR	C-2 凸單孔轉向結合器	4	7430-W10-B1D
<input type="radio"/>	9 C-BENDED ROD	C-3 孔 1/4 弧長條	2	7061-W10-V1D
<input type="radio"/>	10 C-3 HOLE ROD	C-3 孔長條	2	7026-W10-Q2D
<input type="radio"/>	11 C-3 HOLE ROD FRONT CLOSED	C-3 孔長條側有孔	4	7026-W10-X1D
<input type="radio"/>	12 C-3 HOLE ROUND ROD	C-3 孔圓角長條	2	7404-W10-C1D
<input type="radio"/>	13 C-5 HOLE ROD	C-5 孔長條	2	7413-W10-K2D
<input type="radio"/>	14 C-5 HOLE ROD FRONT CLOSED	C-5 孔長條側有孔	4	7413-W10-R1D
<input type="radio"/>	15 C-7 HOLE ROUND ROD	C-7 孔圓角長條	2	7404-W10-C2D
<input type="radio"/>	16 C-7 HOLE PROLATE ROD	C-7 孔圓角扁長條	2	7404-W10-C3D
<input type="radio"/>	17 C-11 HOLE ROD	C-11 孔長條	2	7413-W10-P1D

## 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	ITEM NO. 品號
<input type="radio"/>	18 C-5X5 FRAME	C-5×5 孔正方框	2	7413-W10-Q1D
<input type="radio"/>	19 C-70mm AXLE II	C-70mm II 軸	1	7061-W10-Q1D
<input type="radio"/>	20 C-100mm AXLE III	C-100mm II 軸	1	7413-W10-L2D
<input type="radio"/>	21 C-100mm AXLE III	C-150mm I 軸	1	7026-W10-P1D
<input type="radio"/>	22 C-200mm RUBBER BAND	C-200mm 橡皮筋	2	R10-28
<input type="radio"/>	23 C-20T GEAR	C-20T 齒輪	2	7026-W10-D2S
<input type="radio"/>	24 C-10T CHAIN GEAR	C-10T 鍊輪	1	3569-W10-D2S1
<input type="radio"/>	25 C-70mm RUBBER BAND	C-70mm 橡皮筋	2	R10-02
<input type="radio"/>	26 G-IR IRCAR WHEEL	G- 艾維斯 - 車輪	2	5001-W10-F1D
<input type="radio"/>	27 G-IR IRCAR AXLE	G- 艾維斯 - 輪軸	2	5001-W10-F2D
<input type="radio"/>	28 C-SMALL BODY PIECE RIGHT	C-O 型飾片 (右)	2	7446-W10-A3B
<input type="radio"/>	29 C-80mm RUBBER BAND	C-80mm 橡皮筋	2	R10-33
<input type="radio"/>	30 C-60T WHEEL RIM	C-60T 輪殼	2	7444-W10-A1D
<input type="radio"/>	31 C-MAIN BODY PIECE	C-M 型飾片	1	7445-W10-C1B
<input type="radio"/>	32 C-LARGE BODY PIECE A	C-N 型飾片	2	7446-W10-A1B
<input type="radio"/>	33 C-SMALL BODY PIECE LEFT	C-O 型飾片 (左)	2	7446-W10-A2B
<input type="radio"/>	34 B-PEG REMOVER	B- 扳手	1	7061-W10-B1Y





## CHECK IT OUT 知識補給站

## The Physics of Cars

### POWER

Why is it harder to carry a heavy box while you are running up a flight of stairs than it is while you are walking up the same flight of stairs? It is because it requires more power to move the box when you are running. Power in physics means the amount of work that is done over time.



You may have heard the term horsepower used to describe a car. In the late 1700s, the Scottish engineer James Watt wanted a way to compare the amount of power that a steam engine could produce with that of a draft horse. Watt found that a horse could lift about 33,000 pounds of coal a distance of one foot in one minute. Thus, Watt set one horsepower equal to 33,000 foot-pounds per minute. An average person can produce about 0.1 horsepower, while a car can produce 120 or more horsepower.

### VELOCITY AND SPEED

#### Speed and velocity

are often used interchangeably, but in physics they mean different things. Speed is just how fast something is going, while velocity is both how fast and in what direction.



For example, if you are moving 30 miles per hour, then that is your speed. But, if you are moving 30 miles per hour north, then that is your velocity. The speed of a car is shown by the speedometer in miles per hour or kilometers per hour.



### ACCELERATION

Acceleration is a change in the velocity of an object. That means that the object could be speeding up, slowing down, or changing direction and it would be accelerating. The time it takes for a car to go from 0 to 60 miles per hour is a common measure of a car's ability to accelerate.

### WORK

The way that physicists define work is different from the common usage of the word. Work is when a force causes a displacement in the same direction as the motion of an object. For example, if you were walking around at a steady velocity with a box in your arms you would not be performing work. This is because the force required to hold up the box points in the upward direction, while the displacement from your walking around is in the horizontal direction. However, if you were to push a box along the floor or lift a box up, you would be performing work.



## 汽車物理學

### 功率

為什麼在爬樓梯時，手上拿著沉重的箱子比沒有拿箱子時更困難？這是因為在爬樓梯時你需要更多的動力來移動箱子。物理學中的功率意味著隨著時間的推移完成的工作能量。



你可能聽說過用來描述汽車動力的術語：馬力。在 1700 年代後期，蘇格蘭工程師詹姆斯·瓦特想要找出一種方法來比較蒸汽機產生的功率和一匹馬拉車的功率。瓦特將一匹馬能拉動 33,000 磅並以每分鐘 1 英尺走動的所需要的動力，稱之為 1 馬力。因此，瓦特設置了一個等於每分鐘 33,000 英尺·磅力／分鐘的功率。普通人可以產生大約 0.1 馬力，而一輛汽車可以產生至少 120 以上的馬力。

### 速度和速率

速率和速度經常交替使用，但在物理學中它們有不同的定義。速率只是一個東西移動的快慢；而速度跟向量一樣，既能顯示移動的快慢，又可知道物體朝哪個方向移動。



例如，如果你每小時移動 30 英里，那麼這就是你的速率。但是，如果你每小時向北移動 30 英里，那麼這就是你的速度。可用以英里／小時或公里／小時表示汽車移動的速率。



### 加速度

加速度是物體在一定時間內的速度變化。這意味著物體可能會加速、減速或改變方向，而這就是加速度。汽車從 0 加速到 60 英里所需的時間是衡量汽車加速能力的常用指標。

### 功

物理學家定義「功」的方式與該詞的常用用法不同。功是力對位移累積的物理量，是力與位移的乘積。例如，如果你正在以一個穩定的速度四處走動，那麼你就不會執行任何功。這是因為托住箱子所需的力量指向上方，而你四處走動的位移是在水平方向。但是，如果你要在地板上推箱子或抬起一個箱子，那麼你就有功。





## OVERVIEW 概述



Desert Racer  
沙漠賽車手

Catapult  
投石機



Motorcycle  
Launcher  
摩托車發射器



Wind Mobile  
風動儀

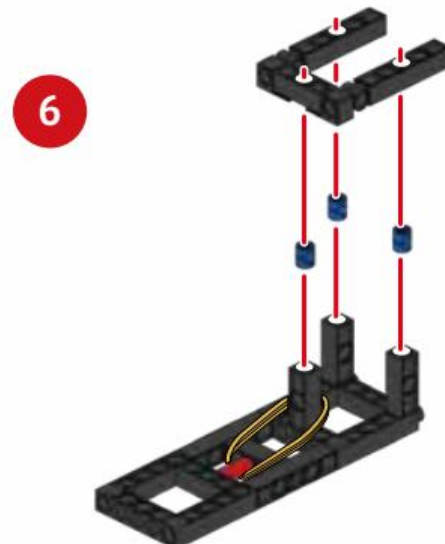
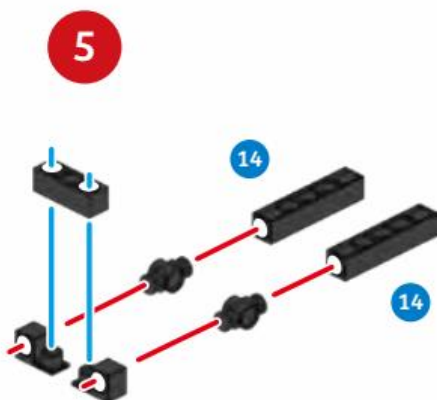
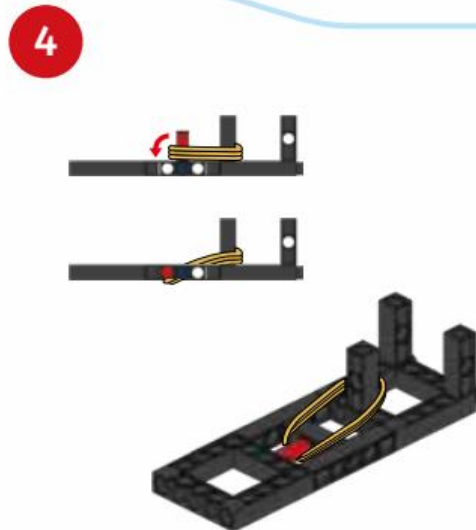
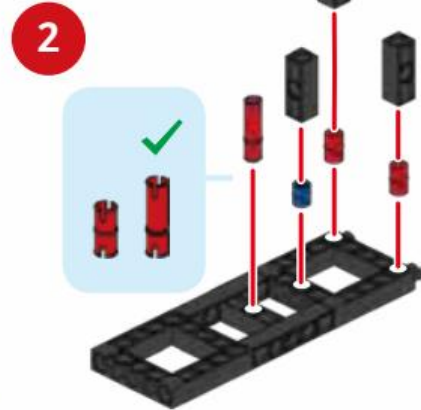
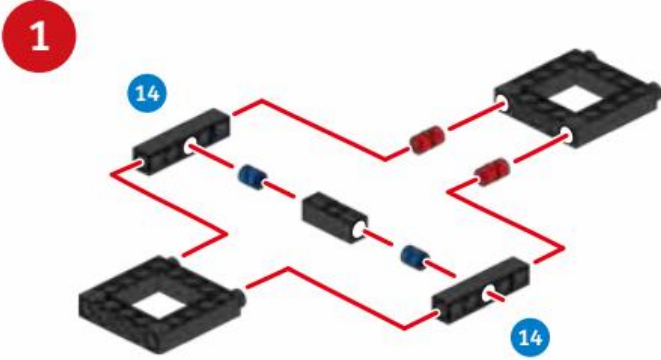


Balancing  
Dragonfly  
平衡蜻蜓





## Model 模型 1 Desert Racer 沙漠賽車手

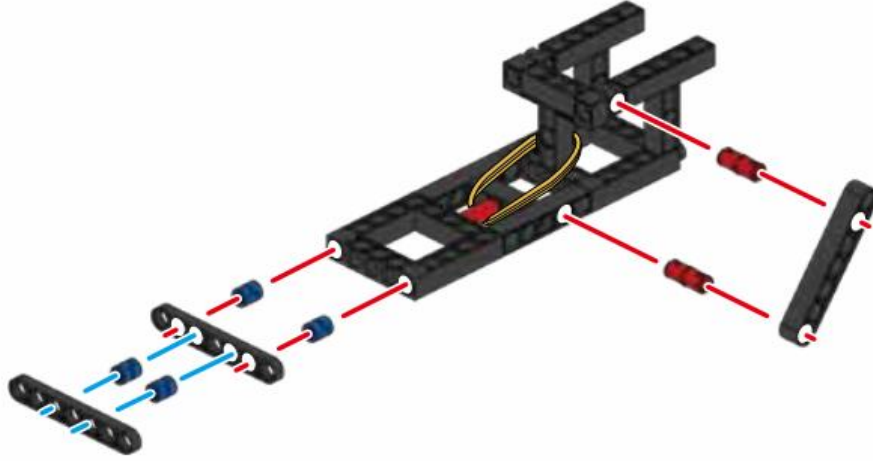




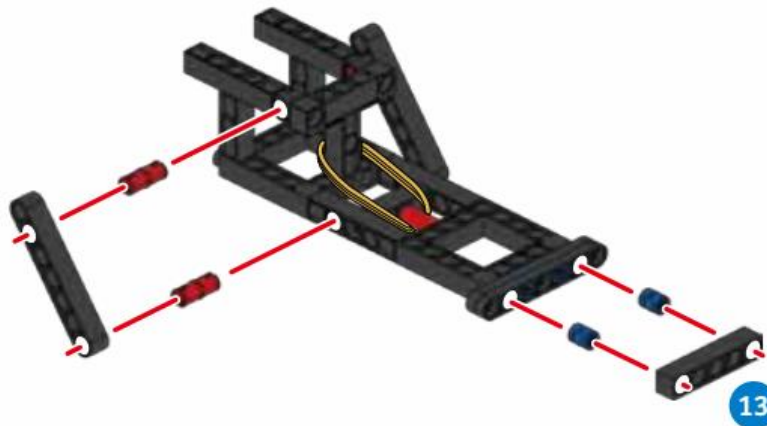


## 沙漠賽車手 Desert Racer Model 模型 1

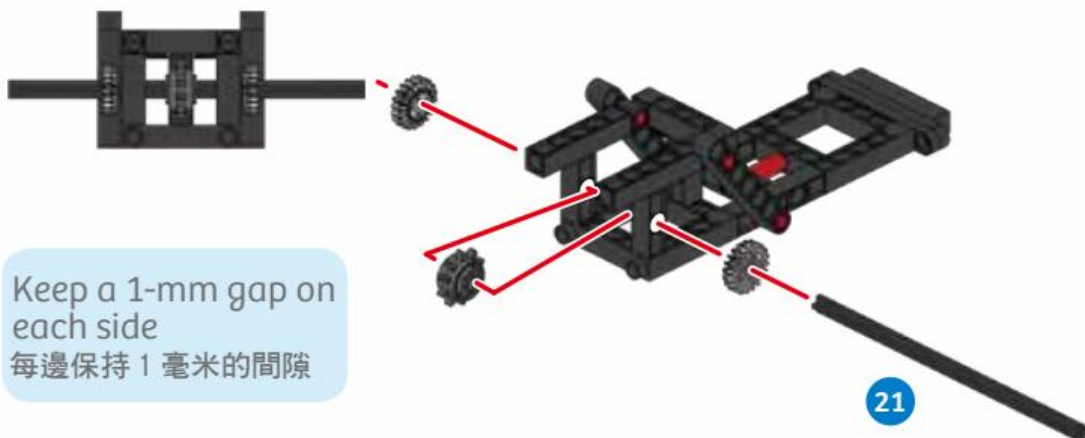
7



8



9



Keep a 1-mm gap on each side  
每邊保持 1 毫米的間隙



Model 模型 1 Desert Racer 沙漠賽車手

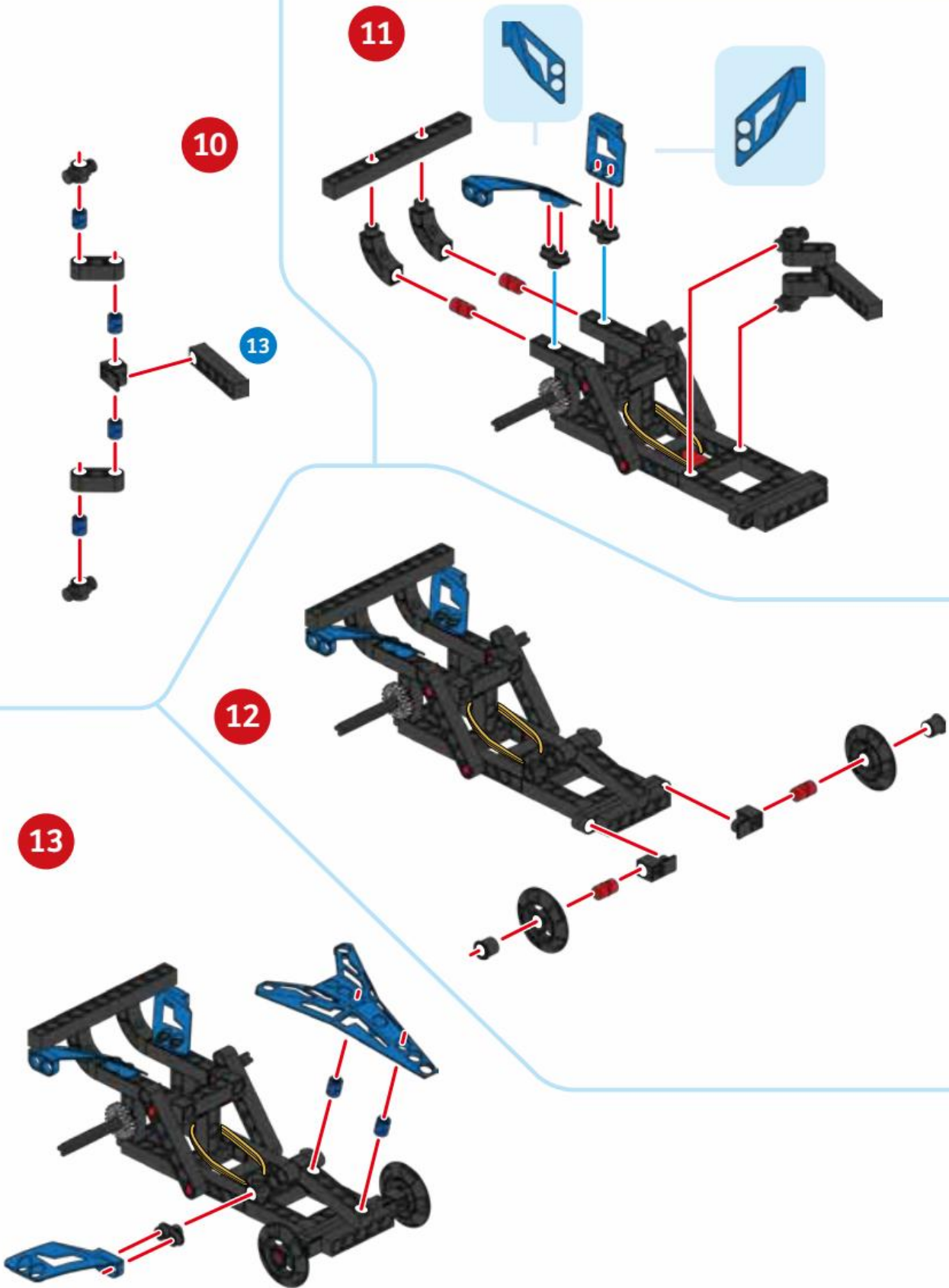
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10

13

12

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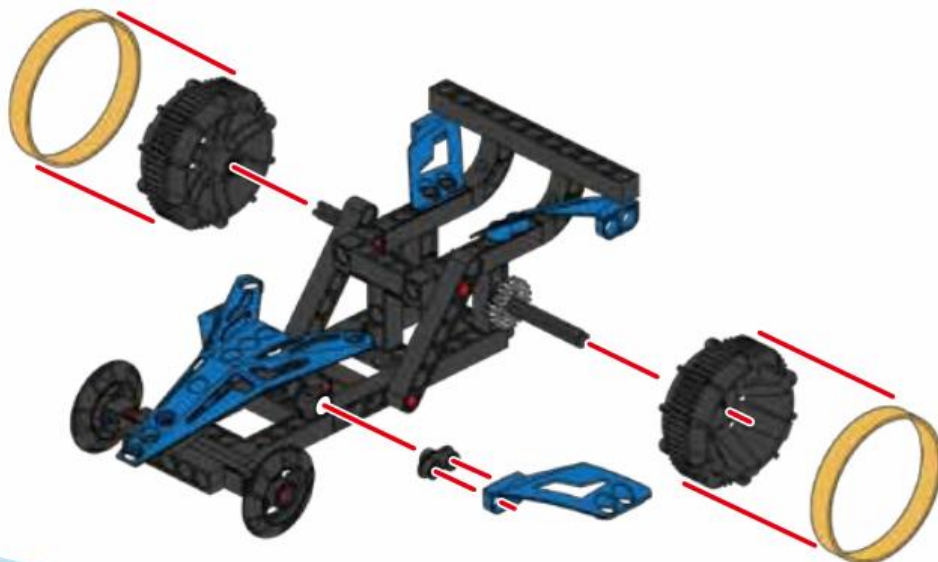






沙漠賽車手 Desert Racer Model 模型 1

14



15



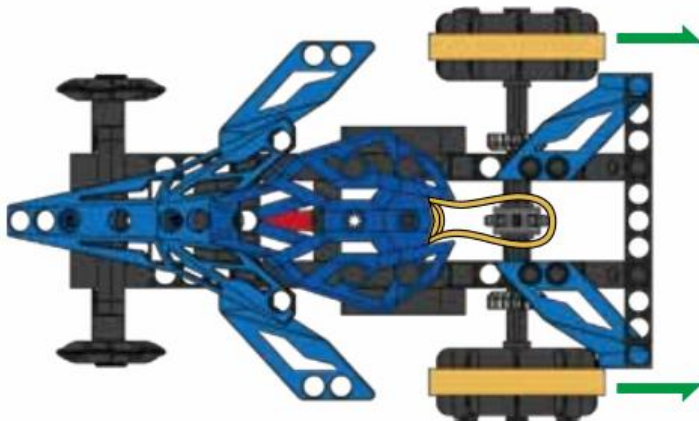
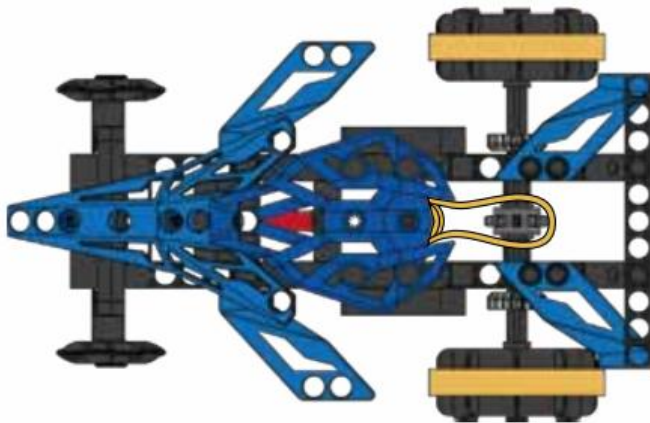
16



Done!  
完成!



## Model 模型 1 Desert Racer 沙漠賽車手



1. Place the car on a smooth, flat floor.

1. 將汽車放在光滑平坦的地板上。

2. Pick one loop of the rubber band and hook it onto the small sprocket.

2. 將一個橡皮筋掛在小鏈輪上。

3. Pull the race car backwards. The small sprocket will wind up the rubber band.

3. 將賽車往後拉。小鏈輪會捲起橡筋。

4. Release the car and watch it go!

4. 放開汽車並觀察它的行進。

Model Operation Video  
模型操作影片





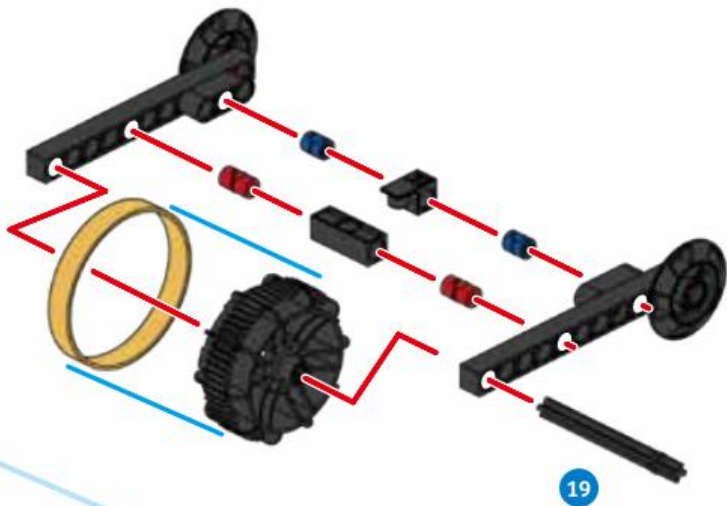


## 摩托車發射器 Motorcycle Launcher Model 模型 2

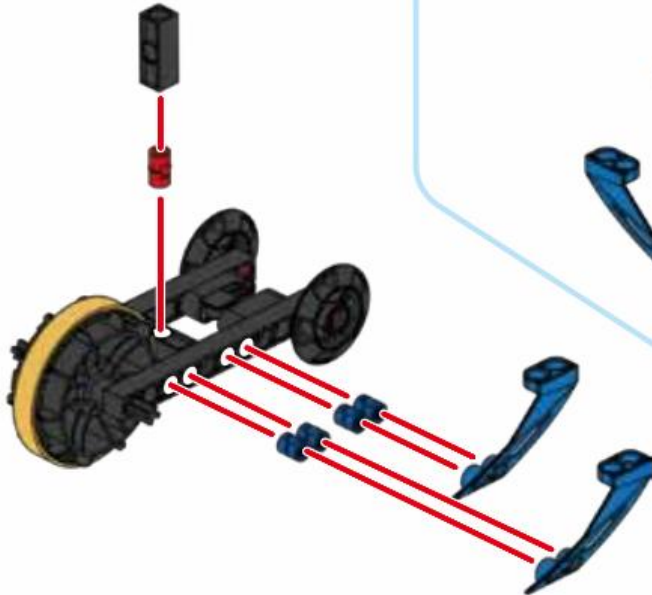
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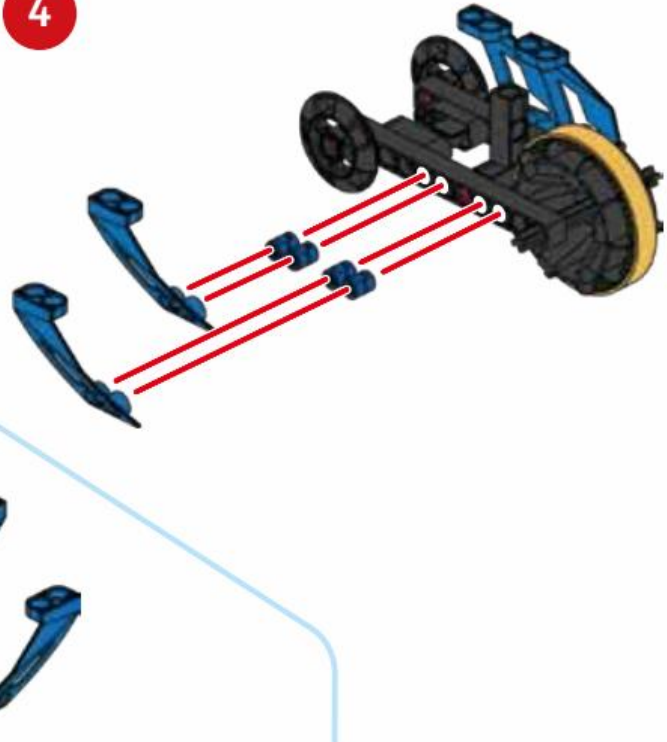
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3

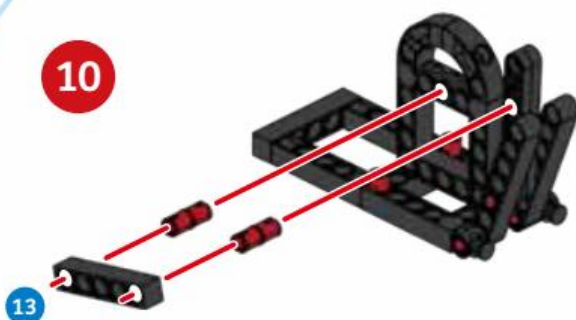
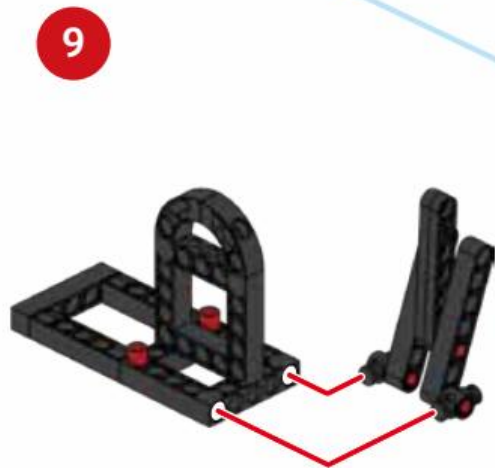
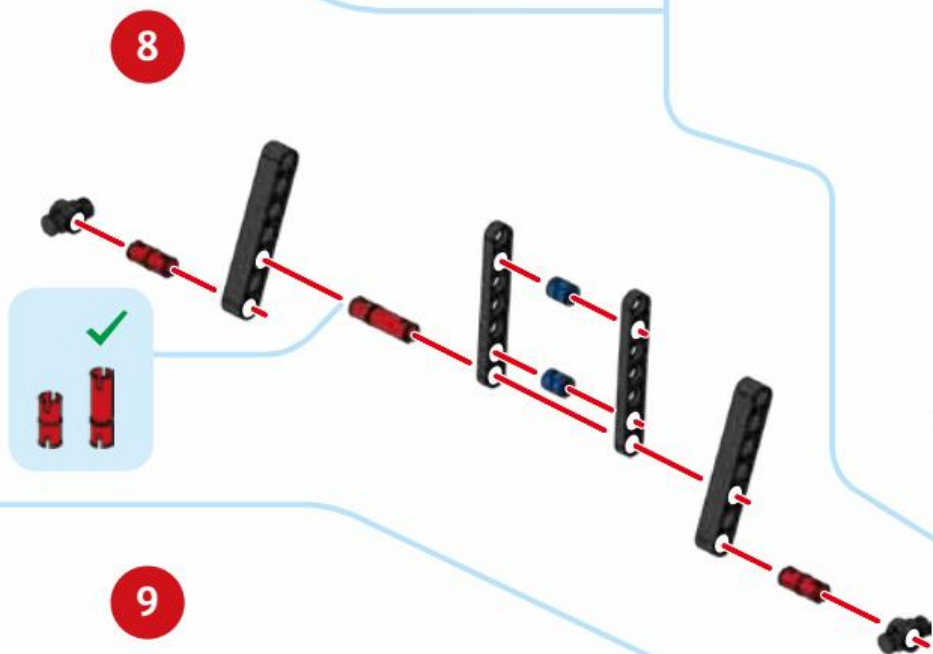
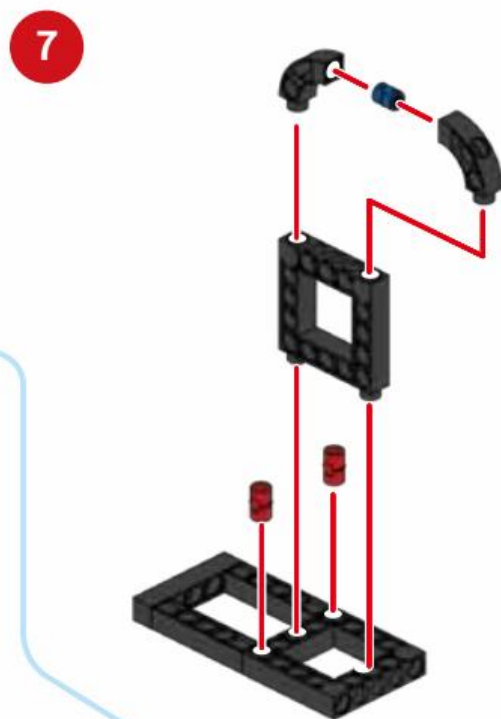
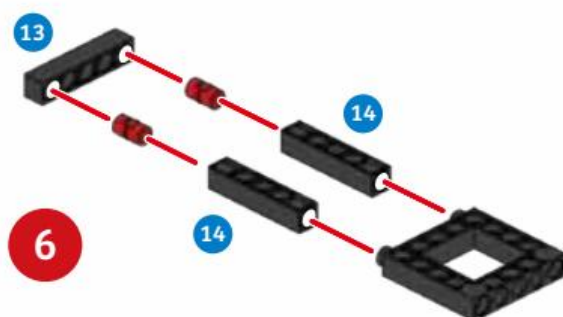
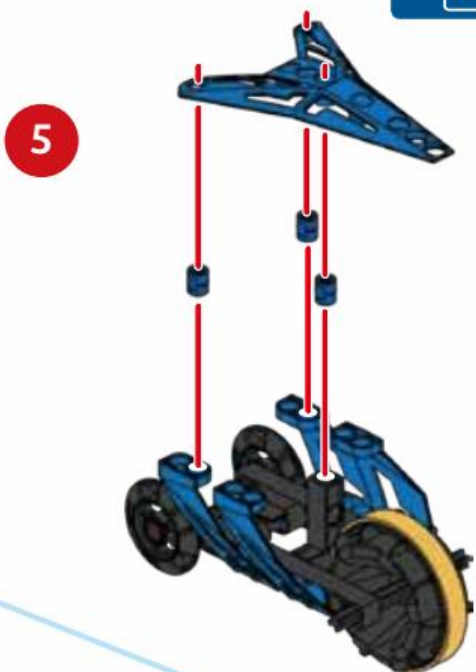


4



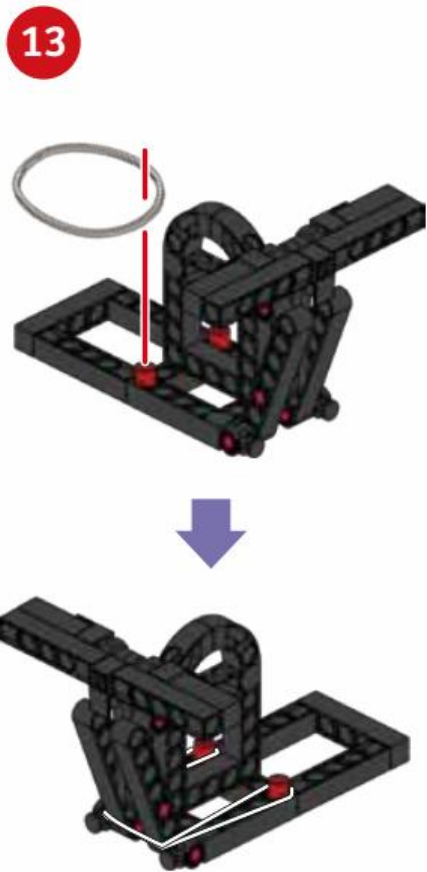
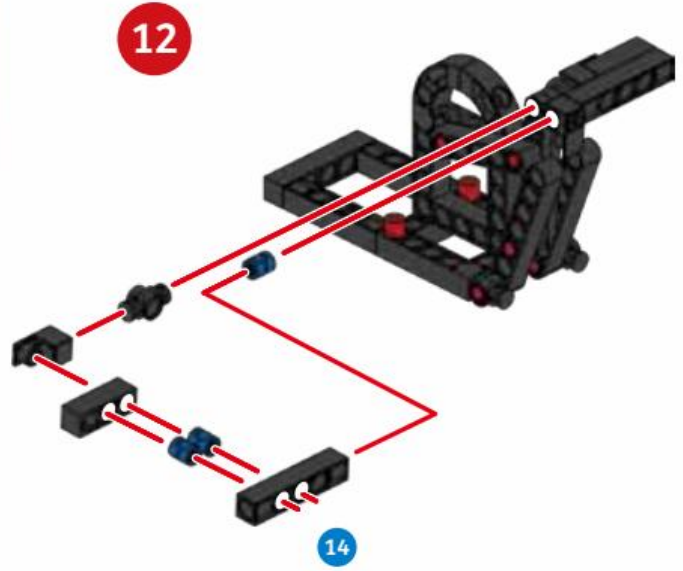
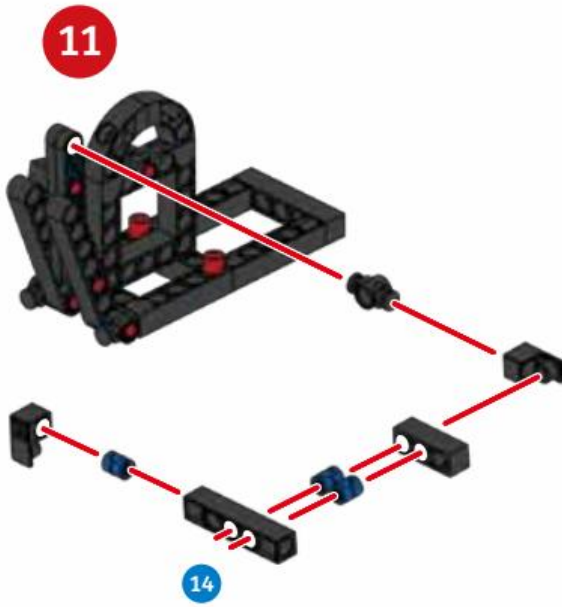


Model 模型 2 Motorcycle Launcher 摩托車發射器





摩托車發射器 Motorcycle Launcher Model 模型 2



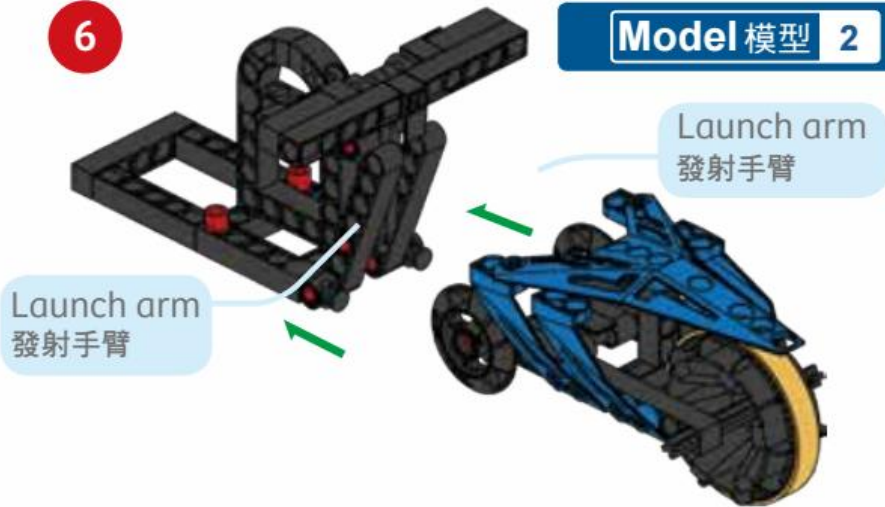
Done!  
完成!





6

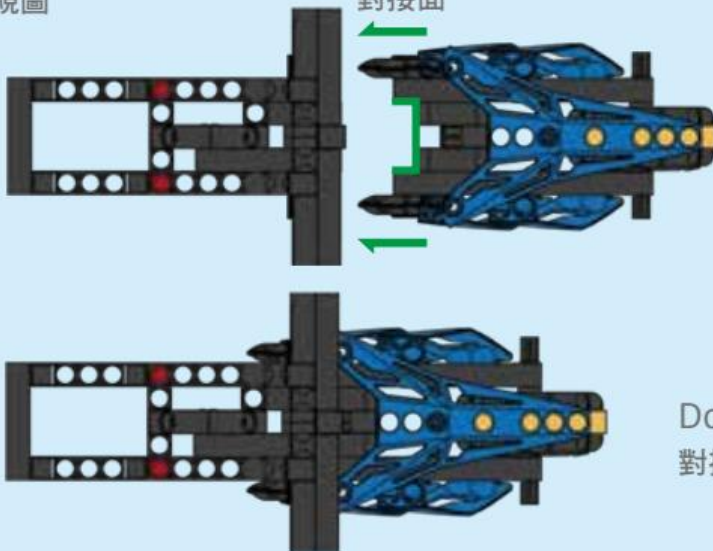
Model 模型 2 Motorcycle Launcher



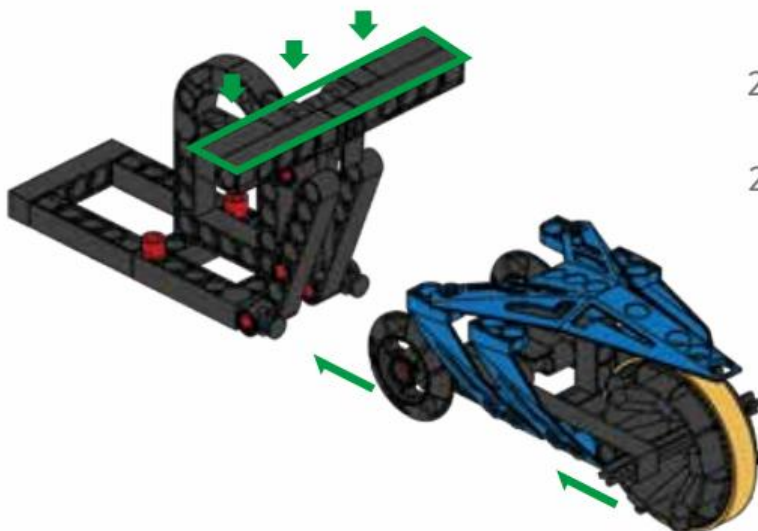
1. Roll the motorcycle backward to dock it onto the launch arm.
1. 將摩托車往後拉，使其停靠在發射臂上。

Top View  
俯視圖

Docking face  
對界面



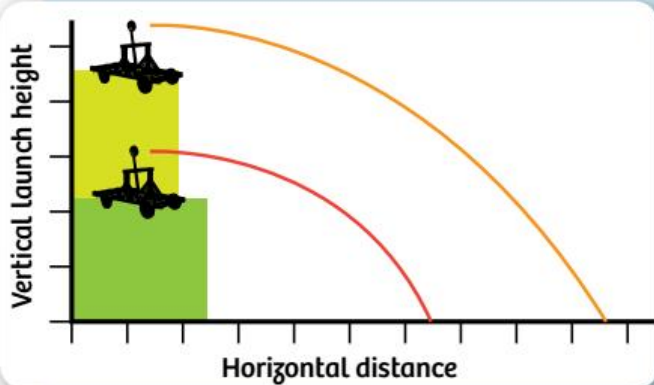
Docking complete  
對接完成



2. Press down on the bar to launch the motorcycle.
2. 按下桿杆以發射摩托車。



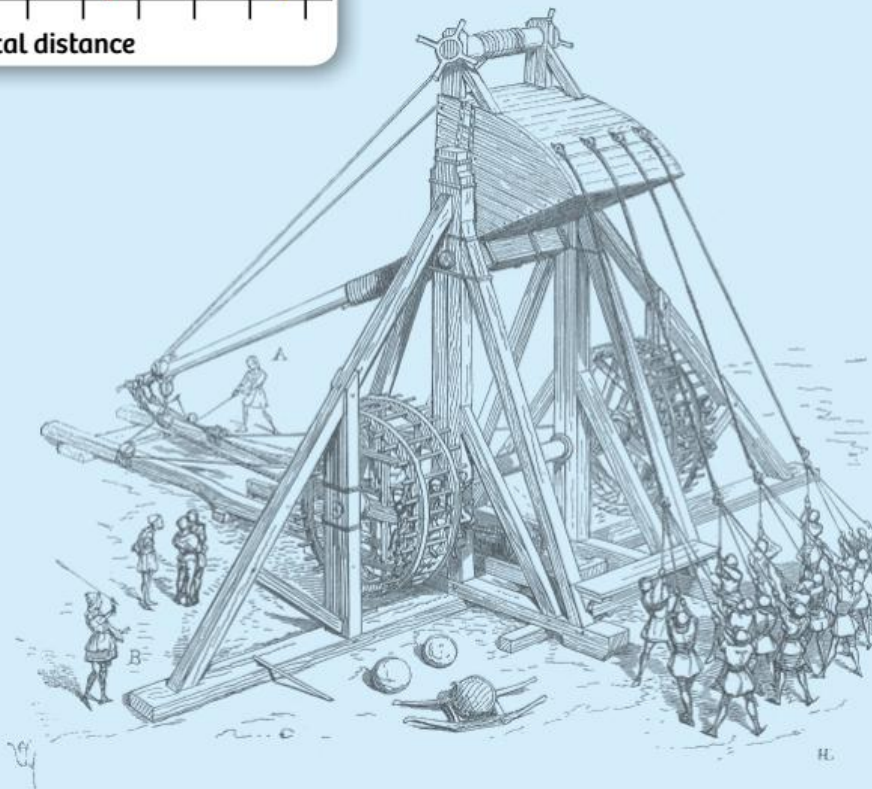
## CHECK IT OUT 知識補給站



## Catapults

The term “catapult” comes from the Ancient Greek word “Katapeltes.” The Ancient Greek Dionysius the Elder of Syracuse invented the catapult around 400 BCE. Early catapults were larger versions of crossbows.

Pictured here is a mangonel. The mangonel is often what people think of when they think of a catapult. Historically, the mangonel was not able to throw projectiles as far or with as great of a velocity as other types of catapults, such as the trebuchet. This is because a lot of the energy goes into accelerating the arm itself which means less energy goes into the projectile.



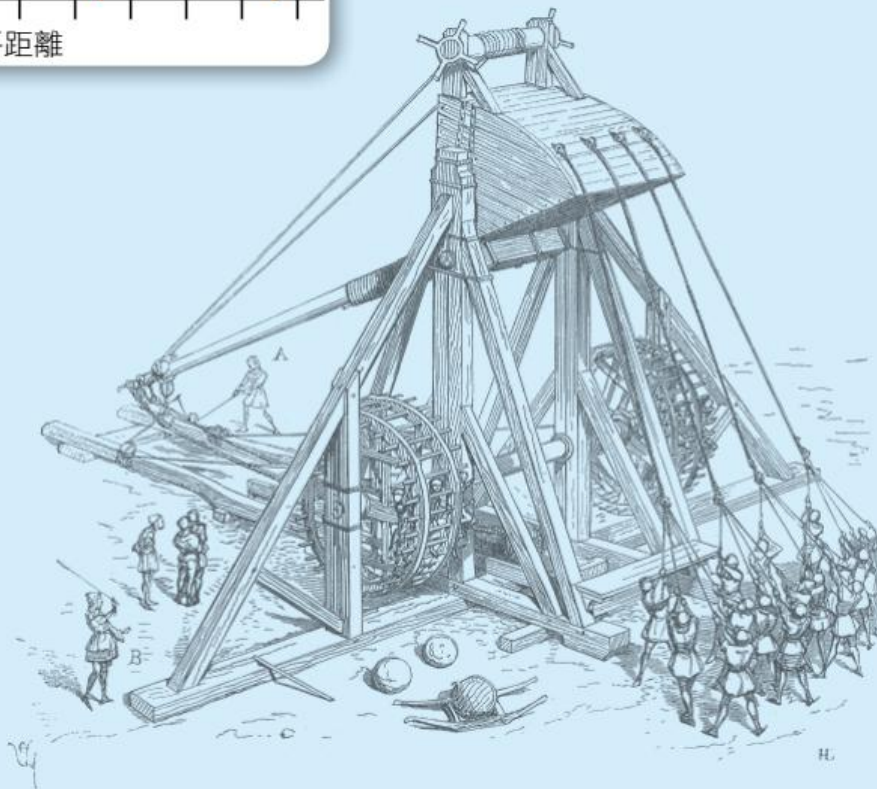
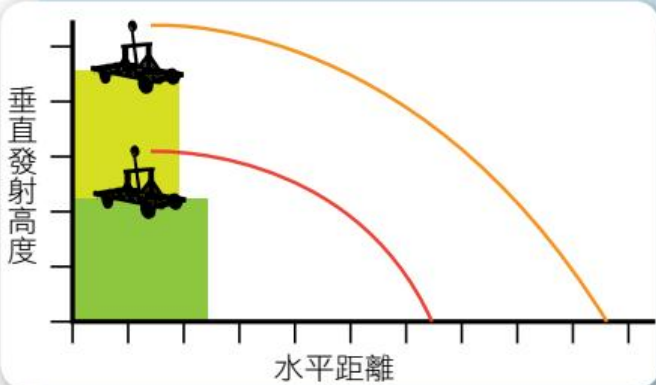


## CHECK IT OUT 知識補給站

## 投石機

「投石機」一詞來自古希臘文的“Katapeltes”。古希臘狄奧尼西奧斯一世在大約公元前 400 年發明了投石機。早期的投石機是較大型的弩（十字弓）。

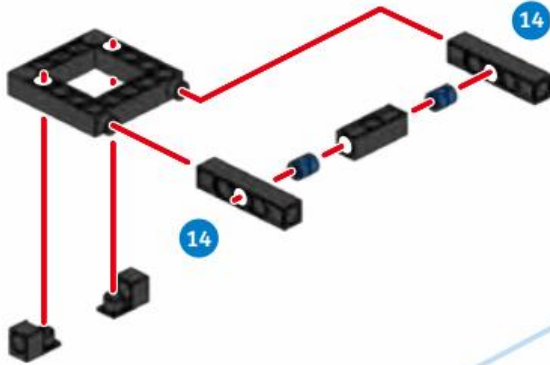
這裡的圖片是一個牽引拋石機。往往人們提到投石機時，會想到類似牽引拋石機的機構。從歷史上看，牽引拋石機不能像其他類型的投石機那樣投擲遠程射彈或者發射快速射彈。這是因為此機構需施加很多能量在加速手臂上，這意味著作為射彈的石頭只能獲得較少的能量。



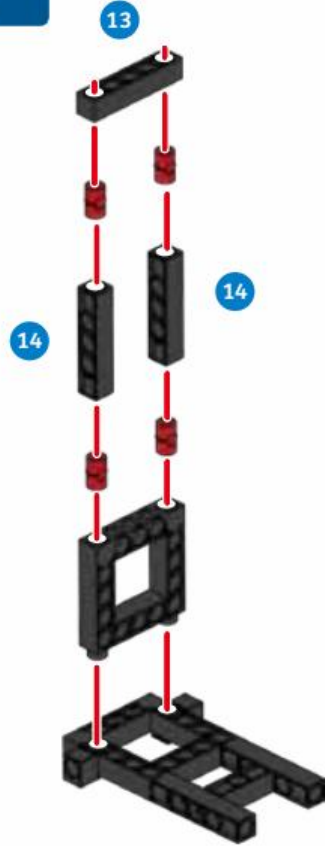


投石機 Catapult Model 模型 3

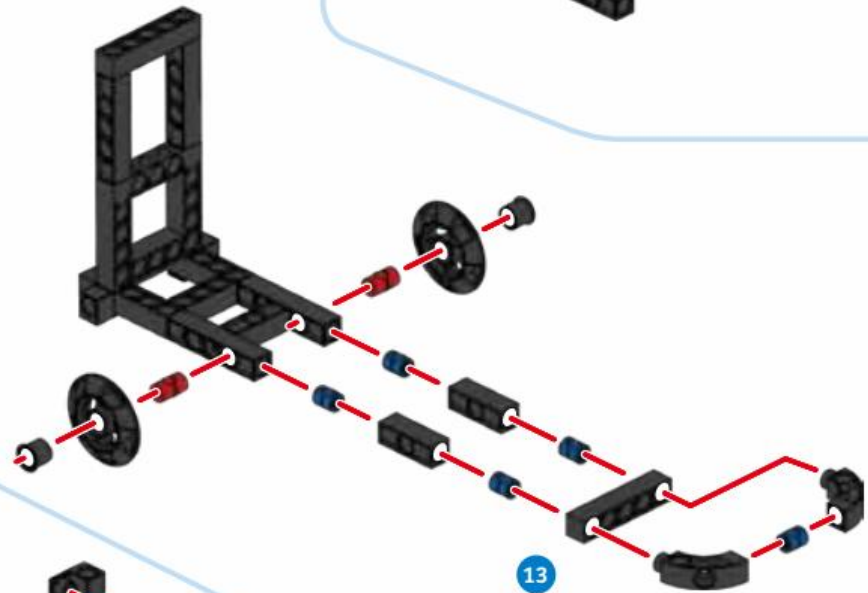
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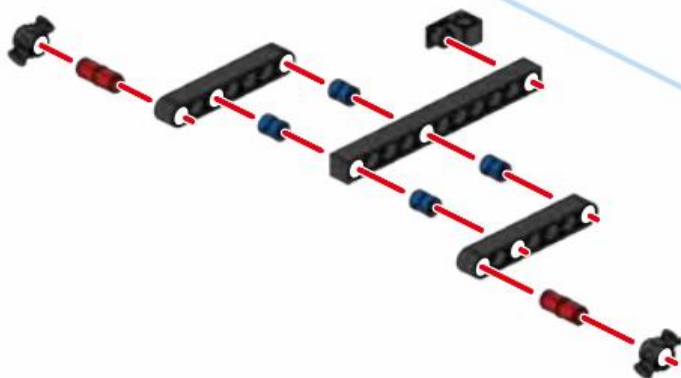
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3

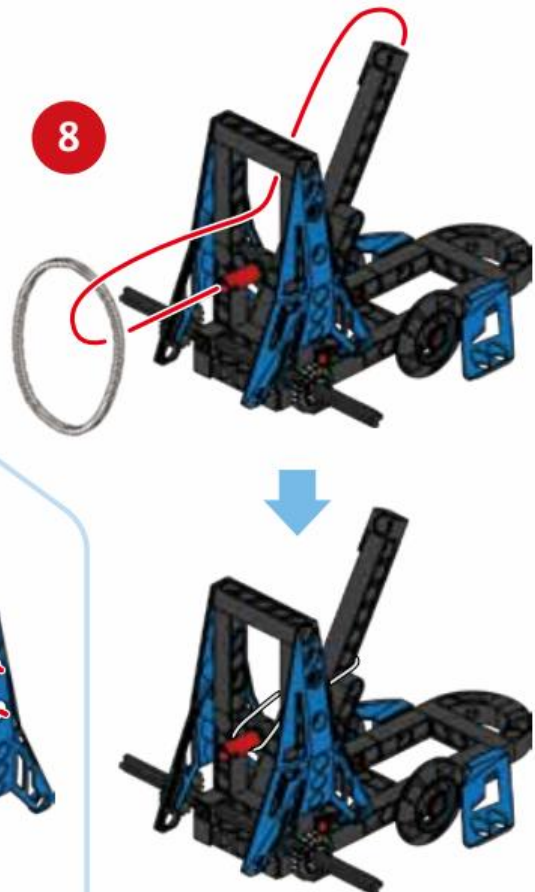
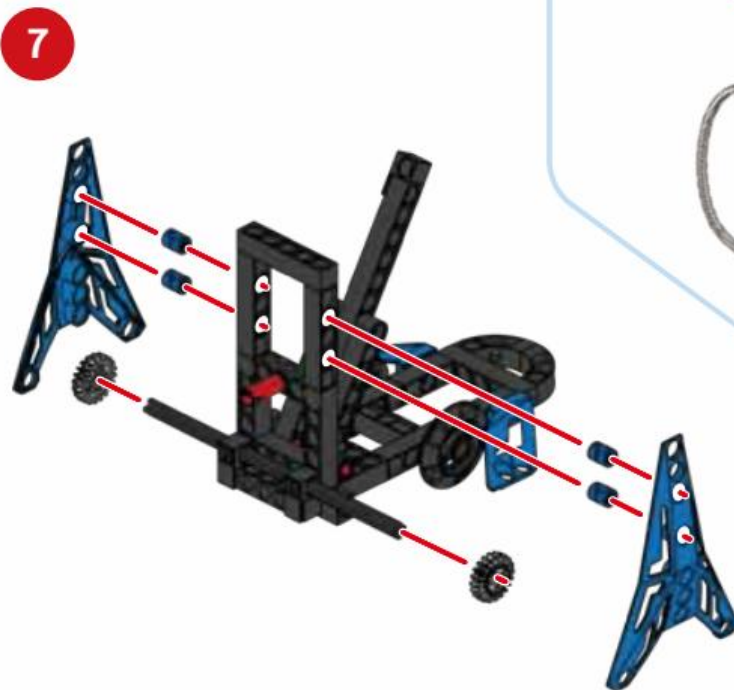
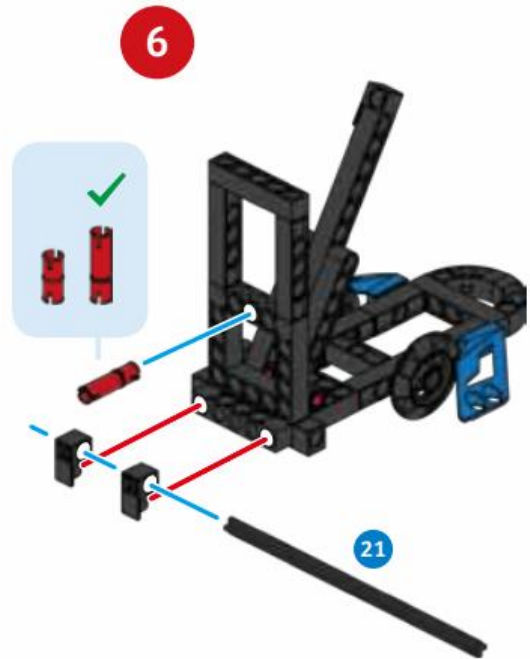


4





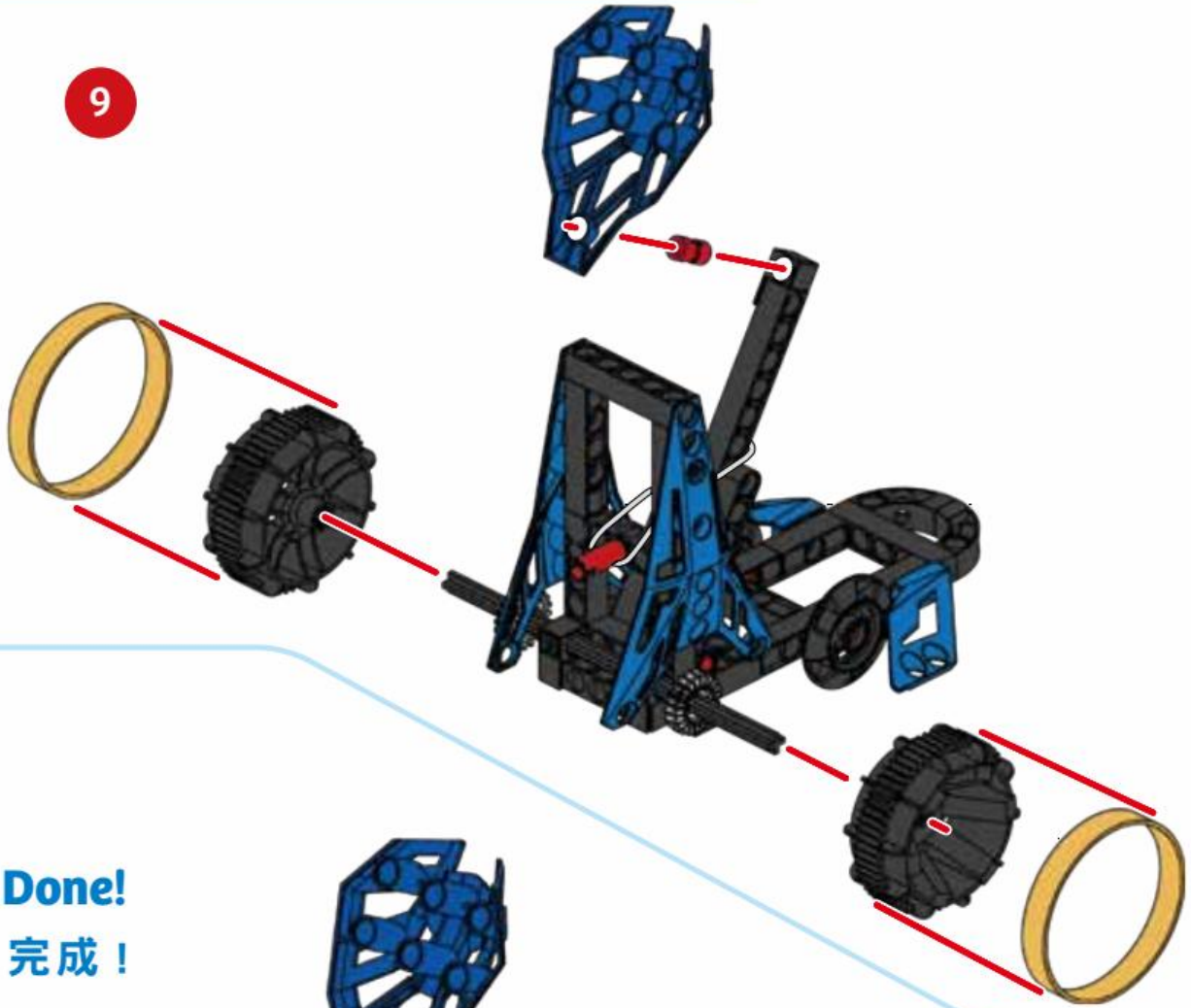
Model 模型 3 Catapult 投石機





## 投石機 Catapult Model 模型 3

9



**Done!**  
完成!



Important! Use balls of crumpled up paper to shoot out of your catapult. Do not use any other objects.

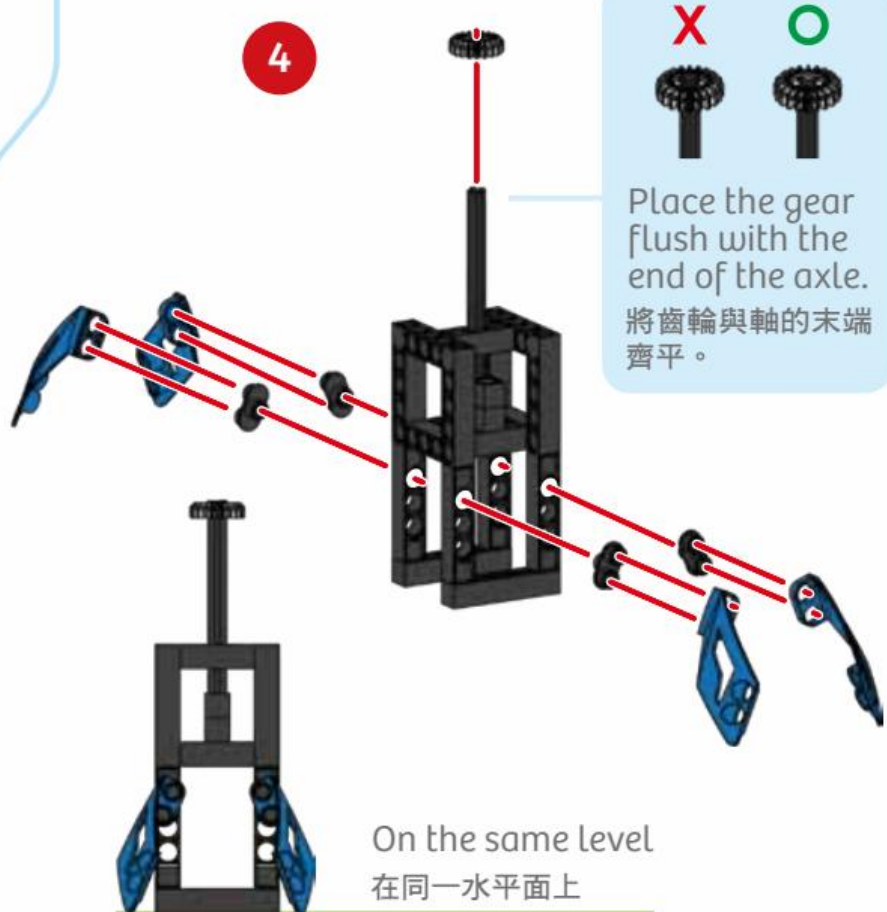
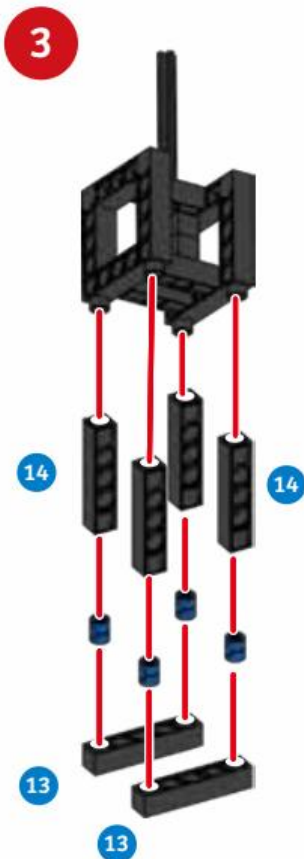
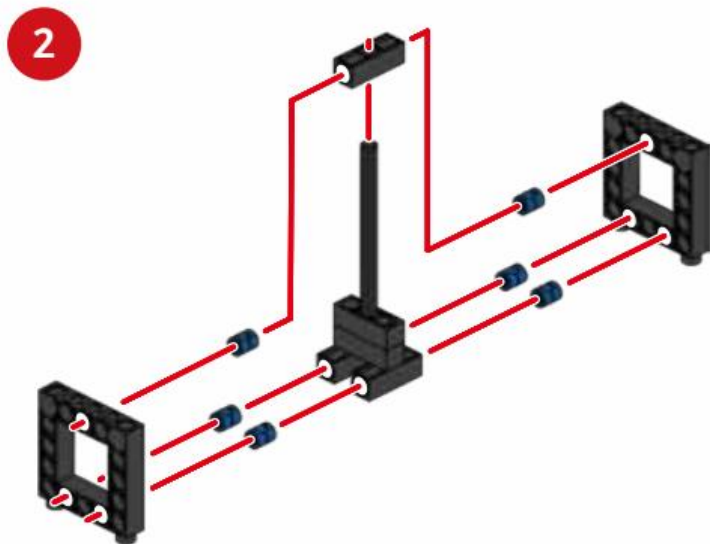
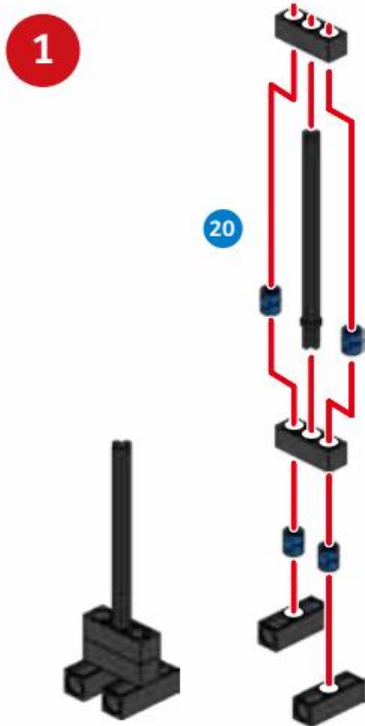
WARNING. Do not aim at eyes or face. Never launch heavy, sharp-pointed, or sharp-edged objects.

重要！只能使用揉皺的紙球作為投石機的射彈。不要使用任何其他物體。

警告。射擊時，不要瞄準眼睛或臉。切勿使用沉重、尖銳或鋒利的物體作為射彈。



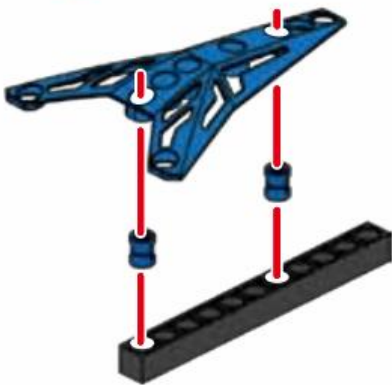
Model 模型 4 Balancing Dragonfly 平衡蜻蜓



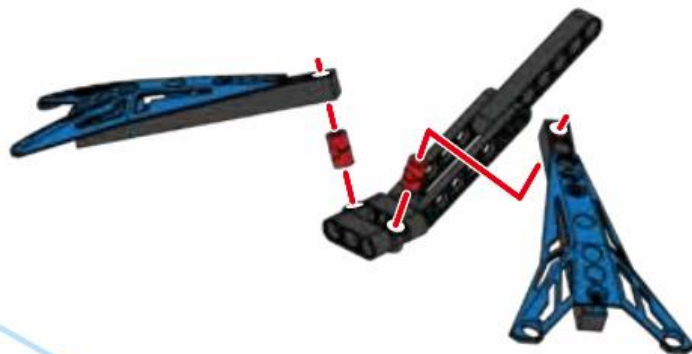


平衡蜻蜓 Balancing Dragonfly Model 模型 4

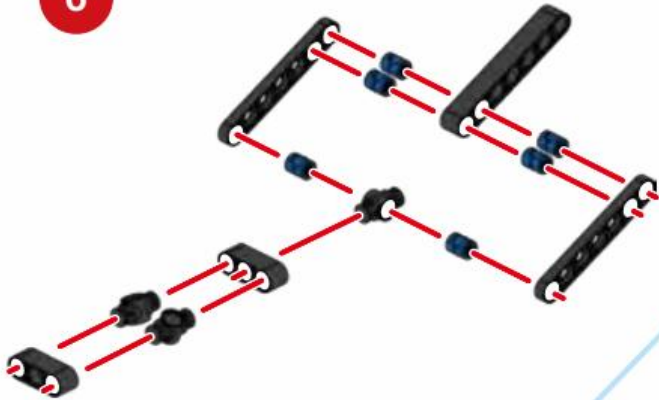
5 x 2



7



6



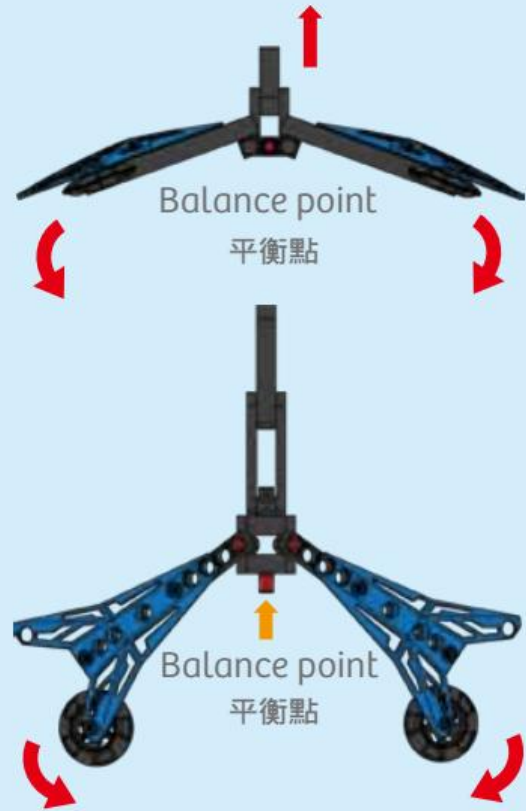
8





## Model 模型 4 Balancing Dragonfly 平衡蜻蜓

9



Adjust the wings into the correct position so the dragonfly is balanced.

調整翅膀到正確的位置，這樣蜻蜓才能保持平衡。

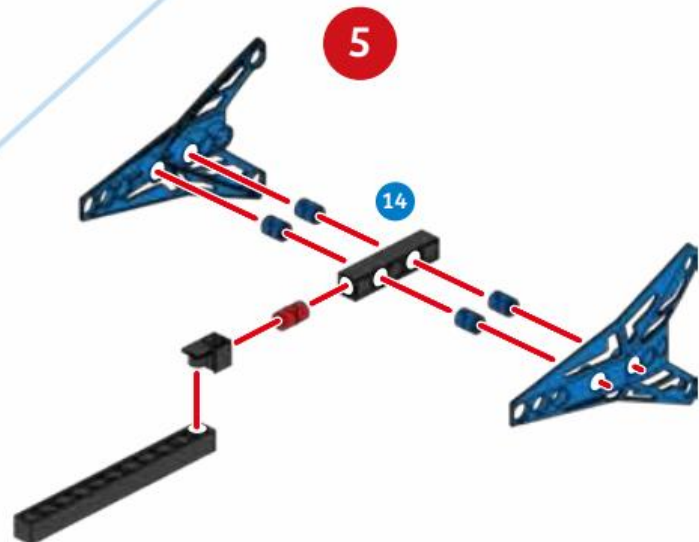
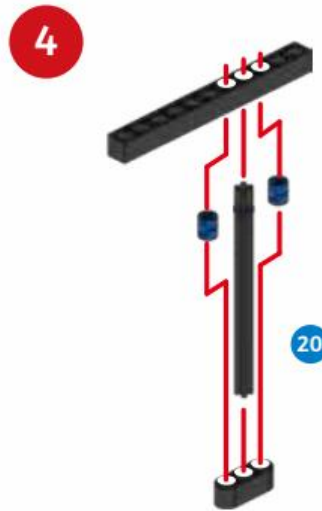
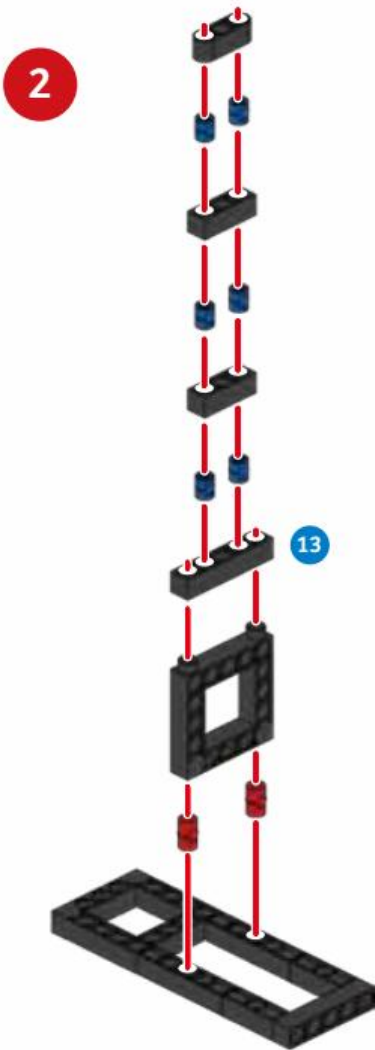
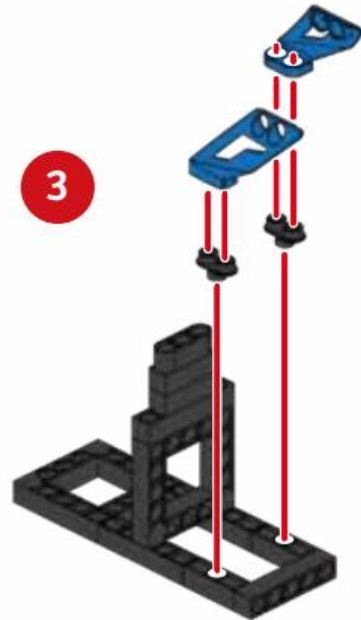
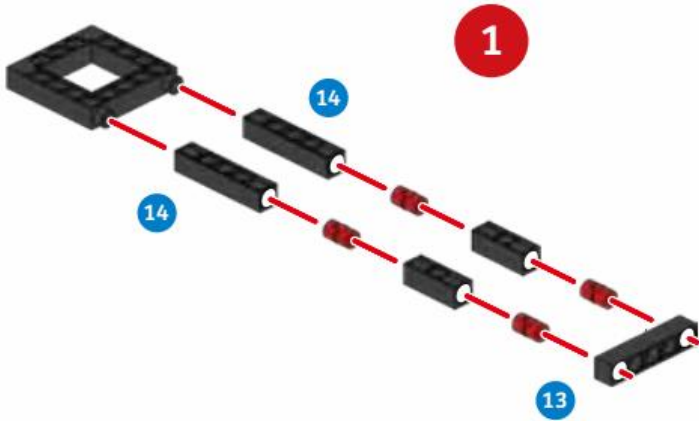
10



**Done!**  
完成！

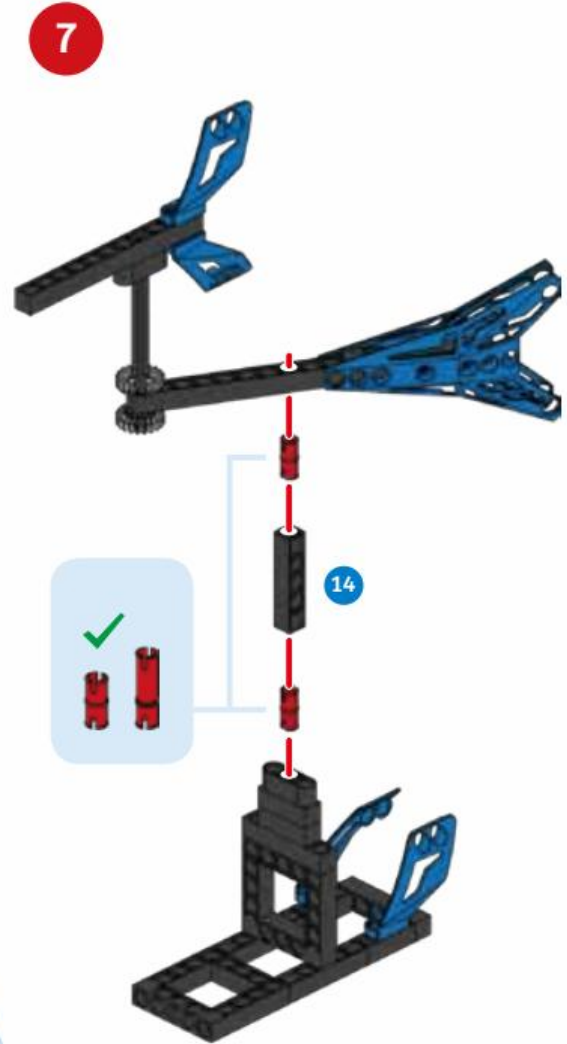
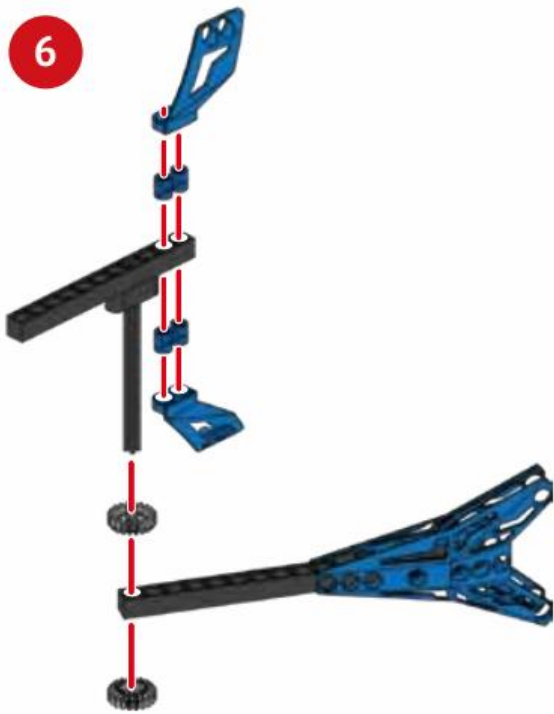


風動儀 Wind Mobile Model 模型 5





Model 模型 5 Wind Mobile 風動儀



Done!  
完成!



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**Your will also have to put energy into your rubber band.**

You can do this thanks to your muscles. When you stretch the band, you're storing **mechanical energy** in it. Because the band is elastic, it instantly tries to revert to its previous shape. In doing so, it releases the energy it had stored, again in the form of mechanical energy. This gives your model the push that it needs. In terms of physics, winding up a rubber band is work that you perform.



Therefore, the energy that is stored in the rubber band is stored work. Your model can then use this energy to perform other work, such as rolling forward or catapulting a ball, for example.



**This trick is also used by tight-rope walkers at the circus:**

The dragonfly's center of gravity is located beneath its support point. This is due to the downward angle of the "wings." These are comparatively heavy. This means that the dragonfly is not really balancing — it only looks as if it is — instead, it is essentially hanging from the point. However, this actually makes it far more stable, and prevents it from toppling over if you give it a little nudge.



## CHECK IT OUT 知識補給站

## 你必須把力量施加到橡皮筋上。

你可以通過肌肉做到這一點。當你拉長橡皮筋時，你會在其中儲存**機械能量**。由於橡皮筋是有彈性的，它能立即恢復到原來的形狀。同時，它再次以機械能的形式釋放它儲存的能量。這能為你的模型提供了所需的推動力。

在物理學方面，將橡皮筋纏繞後，可以產生功。因此，存儲在橡皮筋中的能量



就是被儲存的功。例如，你的模型可以使用這種能量來執行其他作功，例如向前滾動或彈射球。



## 馬戲團中的走鋼索表演者也是使用這個技巧：

蜻蜓的重心位於其支撐點之下。

這是由於「翅膀」的向下角度。這些兩端的翅膀比較重。這意味著蜻蜓沒有真正的平衡——它只是看起來好像是。相反地，它本質上是懸吊在支撐點上的。但是，這實際上使得蜻蜓更加穩定，而且使它不容易因為被碰撞而產生翻倒的情況。





## CHECK IT OUT 知識補給站



**The models that you built in this experiment kit move because of the energy that is stored in them.**

The same applies to cars. The only difference is that cars store their energy in their gas tanks while your models use a rubber band for energy storage.

Cars must be fueled up so that they can drive. This means that the chemical energy is found in the gasoline — when the gasoline is burned in the engine, the energy is released as heat. The pressure of the resulting hot combustion gases is what sets the engine in motion.

**The chemical energy found in gasoline is converted into mechanical energy, namely motion.**

## CONSERVATION OF ENERGY

An important **law of physics** is that energy remains constant. This means that energy cannot be created or destroyed or used up. When we talk about energy being “used up” we are actually describing energy being converted from one form to another.



## CHECK IT OUT 知識補給站



由於有了存儲在其中的能量，建立的模型才能以移動。

這同樣適用於汽車。唯一的區別是，汽車將能源儲存在汽油箱中，而你的汽車模型則是使用橡皮圈來儲能。

汽車必須加油才能行駛。汽油中含有化學能——當汽油在引擎中燃燒時，能量以熱量釋放。產生的熱燃燒氣體的壓力是引擎運轉的原因。



汽油中的化學能可以被轉化為機械能，亦可稱之為運動。

## 能量守恆

物理學的其中一個重要定律是能量守恆定律：能量不能被創造、銷毀或用完。當我們談到能量被「耗盡」時，我們實際上描述的是能量從一種形式轉換為另一種形式。



# EXPERIMENTS



STRUCTURAL ENGINEERING  
BRIDGES & SKYSCRAPERS  
結構密碼-橋樑與摩天大樓  
#7410  
25 Models to build  
323 PCS



MECHANICAL ENGINEERING  
ROBOTIC ARMS  
氣壓動能機械手臂  
#7411  
6 Models to build  
204 PCS



CROSSBOWS & CATAPULTS  
城堡攻防戰  
#7406  
10 Models to build  
110 PCS



RCM CONSTRUCTION VEHICLES  
萬能工程車  
#7408  
8 Models to build  
227 PCS



MINI GYRO  
陀螺儀飛輪機器人  
#7395  
20 Models to build  
88 PCS



GECKOBOT  
爬牆機器人  
#7409  
7 Models to build  
176 PCS



ENGINEERING MAKERSPACE  
GEARED-UP GADGETS  
創客工程:齒輪彈力組  
#7443  
5 Models to build  
114 PCS



ENGINEERING MAKERSPACE  
ALIEN ROBOTS  
創客工程:機械魔獸  
#7445  
10 Models to build  
138 PCS



ENGINEERING MAKERSPACE  
OFF-ROAD ROVERS  
創客工程:動能履帶車  
#7446  
10 Models to build  
118 PCS



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