



Hand2mind MOVING CREATION with K'NEX

動力工程遊戲組-KNEX 建構積木聯名款

中文遊戲說明書



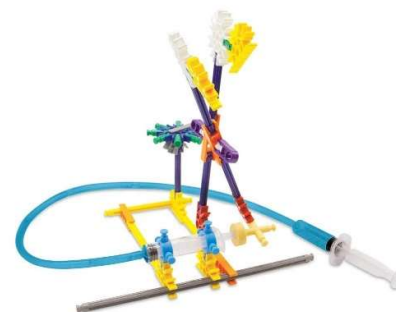
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AIR 空氣動力

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WATER 液體動力

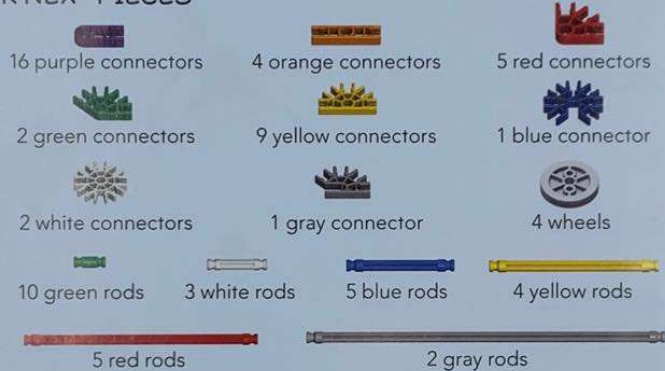
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MATERIALS

The materials needed for each model are included in the set. With these pieces, you will learn how to channel the power of air and water!

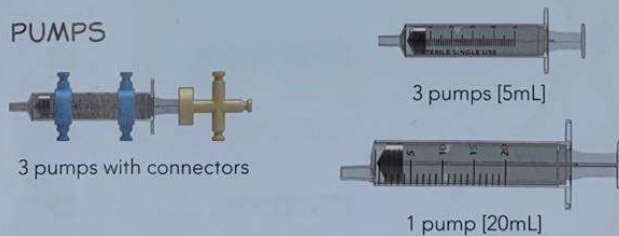
K'NEX® PIECES



TUBES



PUMPS



ROCKET



配件介紹

這些遊戲組的配件在接下來的遊戲活動都會用到！透過連結組裝這些配件，你將會學到氣體以及液體動力如何運作！

K'NEX 配件組

- | | | | |
|-----------|----------|----------|--------|
| 16 個紫色連結器 | 4 個橘色連結器 | 5 個紅色連結器 | |
| 2 個綠色連結器 | 9 個黃色連結器 | 1 個藍色連結器 | |
| 2 個白色連結器 | 1 個灰色連結器 | 4 個輪子 | |
| 10 個綠色桿 | 3 個白色桿 | 5 個藍色桿 | 4 個黃色桿 |
| 5 個紅色桿 | 2 個灰色桿 | | |

管子

- | | |
|---------------|---------------|
| 2 條短管(20inch) | 1 條長管(40inch) |
|---------------|---------------|

幫浦

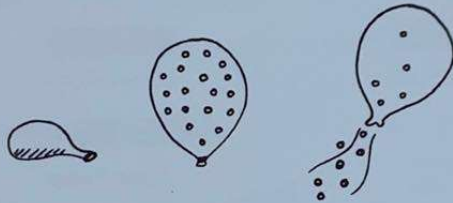
- | | |
|-------------|-------------|
| 3 個帶有連結器的幫浦 | 3 個 5ml 幫浦 |
| | 1 個 20ml 幫浦 |

火箭

WHAT IS PNEUMATICS?

When pressure is put upon air, big things will happen! Jackhammers can bust up pavement. Bicycle tires get filled. Rockets get shot into space. The science of **pneumatics** explains how air and other gases provide power.

Gases are compressible. You can squish them. Take a regular balloon. Let's say you inflate it all the way and then just let go of it. What is it going to do? Fly across the room!



As you blow up a balloon, you are adding more and more air molecules. These air molecules are constantly flying around and bouncing off each other. This causes pressure to build up in the balloon. When you let go of the balloon, all of the air molecules fly out. This releases the pressure in the balloon and propels it across the room.

Jet engines are propelled just like balloons! Air pressure gets released from the engine and this pushes the jet forward.

Bigger and faster pneumatic machines, like jackhammers, have motorized compressors inside them. A compressor is the device that squeezes air into smaller spaces — like a tank. With simpler machines like bicycle pumps, a person's hand compresses the air inside its tubes. Once filled with compressed air, our everyday machines are ready to go!



Jackhammer



Tank



Bicycle Pump

甚麼是氣體動力?

當我們加壓氣體，就會產生不同的變化! 例如鑿地機能夠鑿破人行道，使用幫浦將腳踏車車輪輪胎充氣，火箭藉由氣體動力發射至太空。氣體動力科學解釋了空氣或是其他氣體可以帶來動力!

氣體是可以被壓縮的，換句話說，你可以擠壓氣體。準備一個普通的氣球，將氣球吹飽氣後放開開口放掉氣球，氣球會如何呢? 氣球會在你的房間裡亂飛對吧!

當你往氣球裡吹氣時，你正往氣球(容器)裡加入越來越多的氣體分子，這些氣體分子會在氣球內的空間不斷移動並且相互碰撞，進而在容器內產生壓力。當你放掉氣球後，氣球內被擠壓的氣體分子全部往外跑，同時釋放原本在氣球裡的壓力，讓氣球有動能到處亂飛

飛機引擎的運作原理就像是上述的氣球例子! 氣壓從引擎內釋放出來後推動飛機前進。

更大更快的氣體動力機械，像是鑿地機，內部裝有機動化壓縮裝置(壓縮機)。壓縮機是用來擠壓空氣進入一個更小的空間例如鋼瓶的一種機械。更簡單的氣體動力裝置像是腳踏車幫浦，我們用手或腳按壓腳踏車幫浦時就能將器注入輪胎中，讓我們有更便利的日常生活!

鑿地機

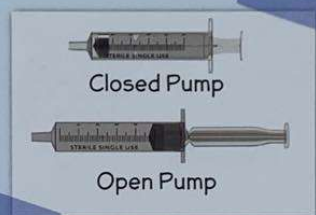
鋼瓶

腳踏車幫浦

PNEUMATICS CRASH COURSE

Before you start building, you must become a Master of Pneumatics. Why should I, you ask? Well, it's practically the most exciting thing that's happened to plain-old air ever. Do you think you can do it? Of course, you can! Give it a try!

MAKE A CLOSED SYSTEM



1. Grab one of the pumps and put it in a closed position. Attach this pump to one end of the tube.

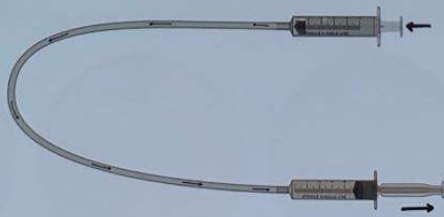


2. Grab the other pump and put it in an open position. Attach this pump to the other end of the tube.



Congrats, you built a closed system! A closed system means that nothing can leave the system. In this case, the air is trapped in the tube.

What happens when you close the open pump? You should notice that the other pump opens! The pumps flip-flopped. This happens because the air from the open pump was pushed into the closed pump.



快速認識氣體動力學

在你開始進行建構積木遊戲之前，你必須先清楚了解氣體動力科學！你可能會問：爲什麼呢？這是因爲看似最平凡普通的空氣，也能帶給你非常刺激且好玩的遊戲樂趣喔！你覺得你能做到嗎？你絕對可以！來試試看吧！

建置一個封閉的系統

1. 拿起一個幫浦，將幫浦柄推進去幫浦內，此時爲關閉幫浦的位置。再將幫浦與一條管子相連結。
2. 再拿取另一個幫浦，把幫浦拉柄拉開，此時爲開啟幫浦的位置。將此幫浦與剛剛那條管子的另一端相連結。

恭喜你！你已經建置了一個封閉的空氣動力系統。封閉系統的意思代表著在系統中的氣體無法脫離，氣體已經被閉鎖在系統裡了。

當你把剛剛處於開啟位置的那個幫浦關閉，會發生什麼事呢？你會發現另一端剛剛處於關閉位置的幫浦開啟了！這是因爲關閉剛剛開啟的幫浦時，幫浦裡的氣體被推擠向另一端的幫浦了。

AIR COMPRESSION



1. Put the 5mL pump in a closed position. Attach this pump to one end of the tube.



2. Put the 20mL pump in an open position. Attach this pump to the other end of the tube.

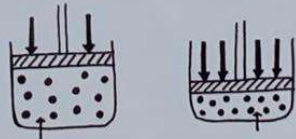


Now, push in the 20mL pump. What do you notice? The pump gets harder and harder to push!

This happens because the volume of the system is decreasing. As the volume gets smaller, the pressure is getting bigger. A bigger pressure means there is more force pushing against the pump. This is why it gets harder to push the pump as the volume decreases.



In 1662, a scientist named Robert Boyle published Boyle's Law. Boyle's Law shows that the pressure of a closed system is proportional to its volume. In other words, as a system gets smaller, the pressure of the gas gets bigger.



壓縮空氣

1. 將 5ml 的幫浦設置在關閉的位置，並將短管連結在幫浦上
2. 將 20ml 的幫浦設置在開啟的位置，並將幫浦連接在短管的另一端。

現在，將 20ml 的幫浦柄推進，你發現了嗎？幫浦越來越難推進了

這是因為這個幫浦系統內的可以容納空氣的空間正在減少。當系統內的容量越來越少時，系統內的壓力會變得愈來愈大，壓力越大也代表有著更強大的力量抵擋你推進幫浦的動作。這就是你感到越來越難推進的原因。

在西元 1662 年，有一位科學家名叫 Robert Boyle 羅伯特·波以耳提出了波以耳-馬略特定律 (Boyle's law)。這個定律指出在密閉容器中的定量氣體，在恆溫下，氣體的壓力和體積成反比關係。也就是說，當容器空間越小時，氣壓越大。

PNEUMATICS TROUBLESHOOTING

Sometimes it can be a little tricky to make a pneumatic system work. That's why it takes an entire team of engineers to build one! As you go, make sure your pumps are positioned on the K'NEX® pieces exactly as shown. If you get stuck while building, come back here for some help.

MY MODEL WON'T MOVE

If your model won't move, check these features of your system:

Are both of my pumps closed? If so, follow these steps to add air back into your system.

1. Detach one of the pump's from the tube.
2. Open the detached pump all the way.
3. Reattach the pump.

Are both of my pumps open? If so, follow these steps to remove air from your system:

1. Detach the free pump.
2. With the tube still attached, close the free pump.
3. Reattach the open free pump.

Are my pumps the correct size?

Double check — a pump that's too small will not create enough force.

MY TUBES FLY OFF THE MODEL

Are you using the correct size pump? Double check—a pump that's too big will push too much force through the system.

IF ALL ELSE FAILS

Sometimes you might have to relieve the pressure in the system. Try disconnecting and reconnecting the pneumatic system. Then give it another go.

關於氣體動力裝置的故障排除

有些時候要製造一個氣體動力裝置並不是那麼的簡單，因此這也是為什麼我們會需要一個工程師團隊來建置一個氣體動力裝置。當你在操作氣體動力部分的積木遊戲時，要確認幫浦與 K'NEX 配件連結的位置都與說明書上圖示相符。如果在建構的過程中卡住或遇到問題，可以回到這頁找尋可能的解決方案。

我的動力工程裝置不會動？

如果你的模型無法動作，試試看確認以下這些事項：

我的兩個幫浦是否同時關閉了？如果是，請依照以下步驟將空氣注回你的幫浦系統。

1. 將其中一個幫浦從系統管子上中移除。
2. 打開移除的幫浦。
3. 再次將幫浦連接回管子。

我的兩個幫浦是否同時開啟了？如果是，請依照以下步驟將空氣從你的幫浦系統移除。

1. 將其中一個幫浦從系統管子上中移除。
2. 關閉移除的幫浦。
3. 再次將幫浦連接回管子。

我是否使用正確規格的幫浦？

再次確認幫浦的規格與說明書上圖示相同，容量太小的幫浦無法使模型正常作動。

我的管子從模型上脫落

檢查你是否使用與說明書上圖示相同正確規格的幫浦。流量太大的幫浦會提供過大的動力使管子脫落。

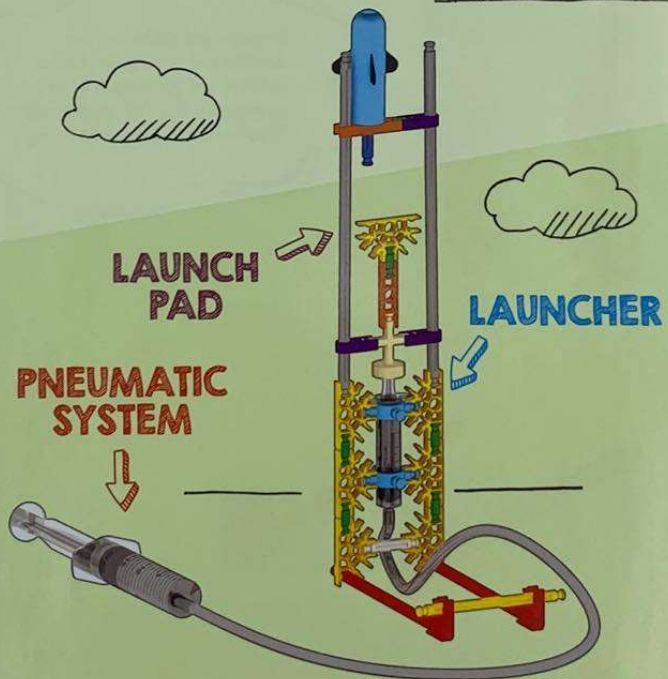
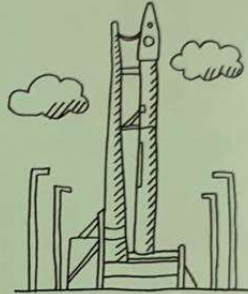
如果這些資訊都無法幫助你解決問題

請先暫時移除氣體動力系統上的幫浦與管線，釋放氣壓後，再次重新連結嘗試動作。

ROCKET LAUNCHER

LET'S BLAST INTO SPACE...

A rocket can travel to the Moon and beyond. But first, it must resist Earth's strong gravity. In this activity, you will build a launch pad that propels your rocket with air pressure.



Moving Creations with **k'nex**

hand2mind.com

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ROCKET LAUNCHER 火箭發射台…………… P9

讓我們一起進入太空世界吧

火箭能夠載著我們移動到月球或是到更遠的地方。但在火箭發射前，我們需要先克服地球重力的問題。在這個遊戲活動中，你將會學習到製作一個火箭發射台並利用氣體的壓力將火箭推射出去。

LAUNCH PAD-發射平台

LAUNCHER-發射器

PNEUMATIC SYSTEM-氣體動力裝置

◆請勿任意複製翻印◆ 版權所有：知蘭文化事業有限公司

甘子玩伴
G d Playmate

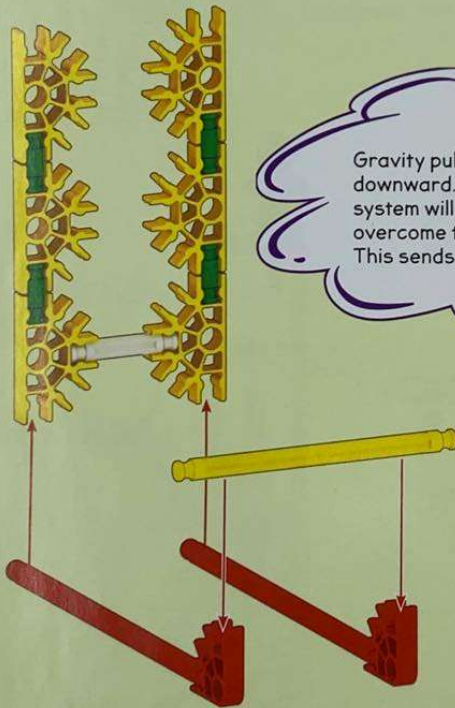
BUILD THE LAUNCHER

STEP 1



GATHER THESE PIECES:

- | | | | |
|---|--|---|--|
| 1 | | 1 | |
| 2 | | 6 | |
| 2 | | 4 | |



Gravity pulls the rocket downward. The pneumatic system will generate energy to overcome the force of gravity. This sends the rocket flying!

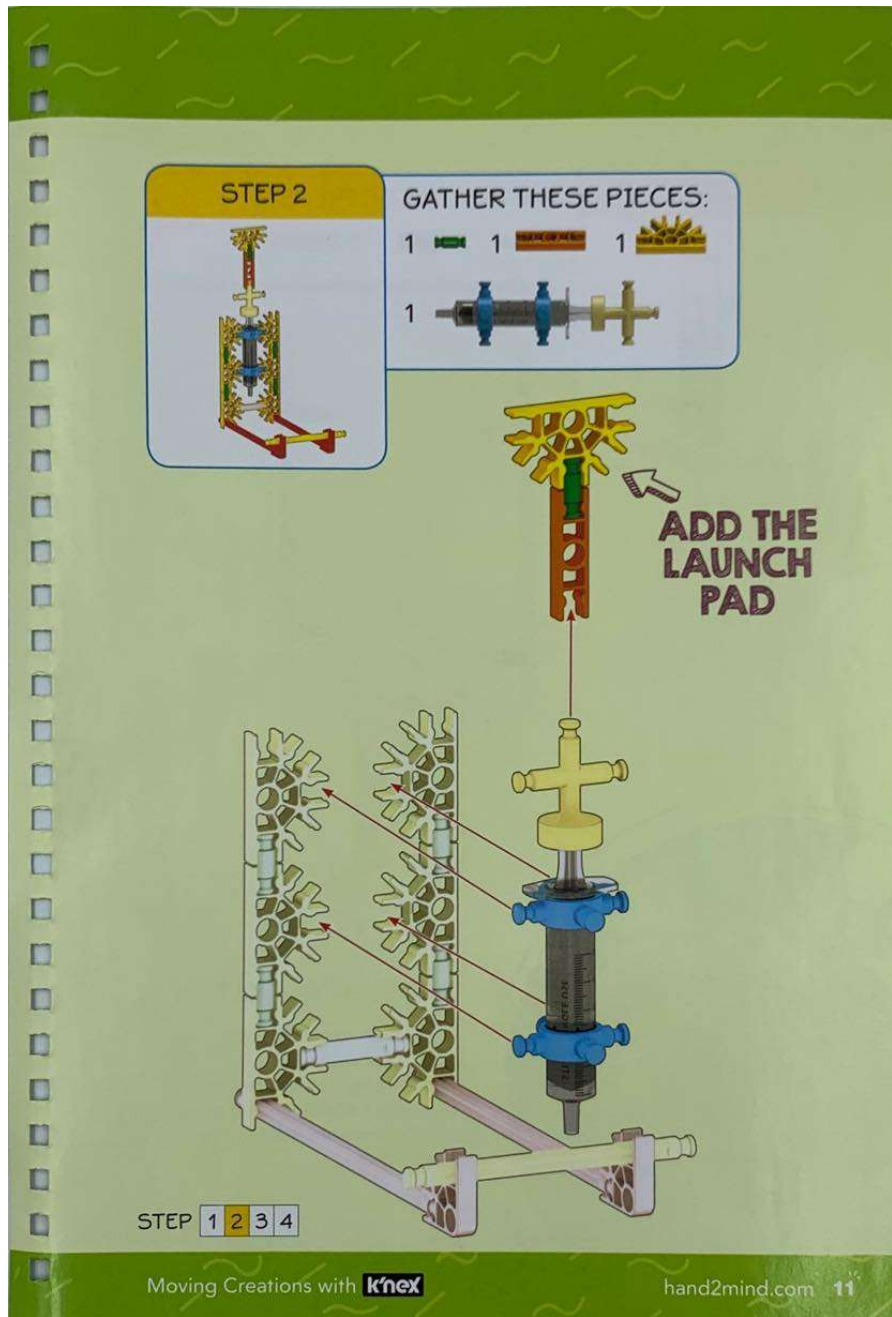
STEP 1 2 3 4

建構火箭發射台

步驟 1

準備以下配件，並照著圖解組裝積木配件

地球的重力會將火箭向下拉。而氣體動力裝置則會產生額外動力抵銷重力，並且推動火箭往天際飛行!



步驟 2

準備以下配件，並照著圖解組裝積木配件

加上發射台



◆請勿任意複製翻印◆ 版權所有：知蘭文化事業有限公司

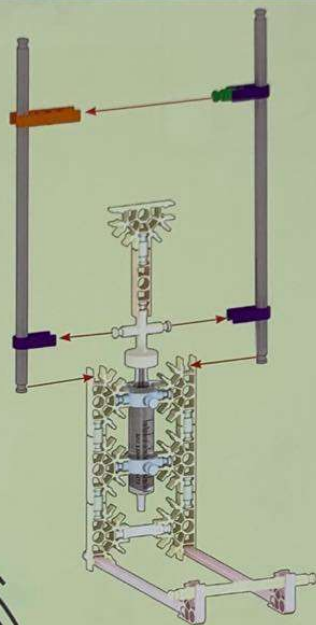


BUILD THE LAUNCHER

STEP 3

GATHER THESE PIECES:

- 1  3  1 
2 



THE FIRST ROCKET

The first documented use of a rocket was in 1232 by the Chinese. However, some historians believe rockets were actually invented hundreds of years earlier!

STEP 1 2 3 4

建構火箭發射台

步驟 3

準備以下配件，並照著圖解組裝積木配件




根據有記載的文件指出第一個使用火箭的是中國人，然而也有部分歷史學家相信火箭在更早幾百年前就已經被發明了。

CONNECT THE PARTS

STEP 4



GATHER THESE PIECES:

- 1 
- 1 
- 1  20mL
- 1 Short Tube



OPEN YOUR PUMP BEFORE CONNECTING THE PARTS



See pages 6-8 for a refresher on how to fill your pump with air and make your model move.

STEP 1 2 3 4

將配件相互連結

步驟 4

準備以下配件，並照著圖解組裝積木配件

將火箭放置定位

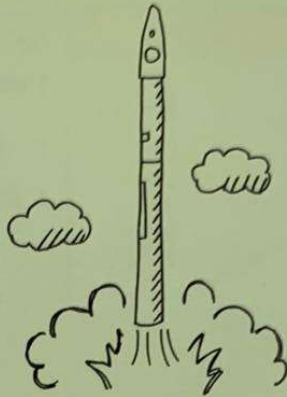
在連結所有配件前先將幫浦打開

可參閱 P5-8 複習一下如何將幫浦充滿氣體以及如何推動模型

IMAGINE!

YOU ARE ON A MISSION TO MARS...

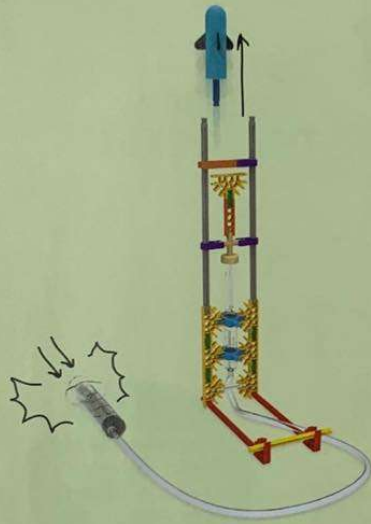
You're a top scientist inside NASA Mission Control. Humankind is about to make history. Your astronaut crew is boarding the spacecraft. The launch pad is ready. You've got seconds to lift-off. 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 ... Let's go!



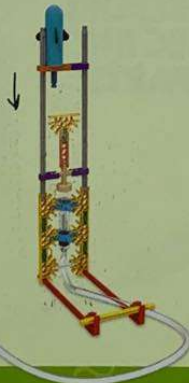
BLAST OFF!

Smack the end of the 20mL pump hard. If your rocket doesn't go far, hit the pump even harder. Watch the rocket fly!

To launch your rocket again, lower the launch pad and put the rocket back in place. Then, pull out the 20mL pump to build air pressure in the tube. On your mark, get set, launch!



⚠ Do not aim rocket at eyes or face.



想像一下

你正在執行一個飛往火星的任務

你變身為一位在 NASA 任務控制中心的頂尖科學家，你的太空飛行員團隊此時正登上火箭，火箭發射台已經準備完畢準備發射，幾秒後你的火箭就要發射！倒數計時 10,9,8,7,6,5,4,3,2,1...火箭發射！

火箭發射

將幫浦用力推進！如果你的火箭飛的不夠遠，重來並再一次用更大的力道去壓幫浦，再看一次火箭如何飛行！


要重新讓火箭再發射一次呢？將發射平台推回原來位置，並將火箭放回發射位置。接著將幫浦拉柄拉開，重新讓氣體注入幫浦產生氣壓！準備就緒，預備，發射！

注意：發射時請勿將火箭朝向臉或眼睛！

THINK BIGGER!

ARE YOU FLIGHT READY?

Attach more K'NEX® pieces to your rocket. How does it fly now? How does weight affect its lift? How much weight can you add and still make it fly?

Sketch of rocket	Weight of rocket	Height of launch
		

According to Newton's Second Law of Motion, it is easier to push an object with a smaller mass than a larger one. It will accelerate faster.

進階思考

你可以嘗試將更多不同的 K'NEX 配件組裝在火箭上，將每一款火箭的外觀畫在表格中，並且記錄每一款火箭的重量以及火箭飛行的高度。觀察火箭的重量是否會影響火箭飛行呢？在維持火箭能夠飛行的前提下，最多我們可以加上多少重量呢？

火箭外觀	火箭重量	火箭飛行高度

根據牛頓的第二運動定律，比起重量較重的物件，重量較輕的物件我們更容易能推動，同時重量較輕的物件在推動後的加速度也會比較快！

THINK BIGGER!

WHAT ELSE COULD YOU TRY?

After launching, rockets move in a curved path in the sky. Launch your rocket, watch closely, and draw the shape it travels in below. Then use K'NEX® pieces to change the rocket. Launch it again and then sketch this flight path too. What's different about them?

Sketch the flight path.



This shape _____ resists air the best.

SPACECRAFT AND ROCKETS

A rocket is like an engine itself. A space shuttle needs a rocket to carry it into space. Since the 1960s, humans, dogs, chimpanzees, and even fruit flies have ridden in spacecraft that were carried by rockets.



進階思考

還有什麼實驗遊戲是你可以嘗試的呢?

在發射火箭後，火箭會以圓弧曲線的軌跡移動。你可以再一次發射火箭，並仔細觀察發射後火箭移動的軌跡，嘗試將軌跡畫在底下；然後再利用其他的 K'NEX 配件組裝成不一樣造型的火箭，再一次發射以及觀察記錄飛行的軌跡，比對軌跡是否有不同之處呢?

哪一種造型的火箭更能抵銷風阻飛得更好更遠呢?

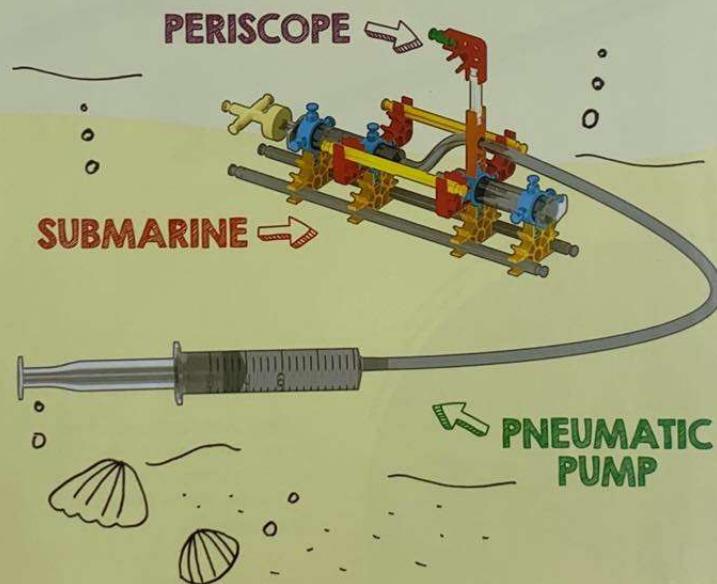
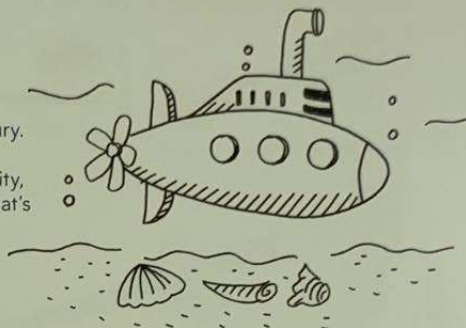
太空飛行器與火箭

火箭本身就像是一個引擎! 而太空飛行器則是需搭載火箭，讓火箭推動太空飛行器! 從西元 1960 年代開始，人類、小狗、黑猩猩、甚至是果蠅都會搭過搭載火箭的太空飛行器前往太空!

SUBMARINE

LET'S DIVE INTO A DEEP, DARK SEA...

Submarines have navigated the seas since the 18th century. They can float like a boat or sink out of sight. In this activity, you will build a submarine that's powered by air.



SUBMARINE 潛水艇.....P17

讓我們一起沉入又深又暗的海底吧

從 18 世紀開始，我們開始用潛水艇還探索深海世界。潛水艇可以像船一樣浮在海面上，也可以沉到海裡。在這個遊戲活動中，你將學到如何利用氣體動力來建構一艘潛水艇。

PERISCOPE 潛望鏡

SUBMARINE 潛水艇

PNEUMATIC PUMMP 氣體動力裝置

BUILD THE SUBMARINE

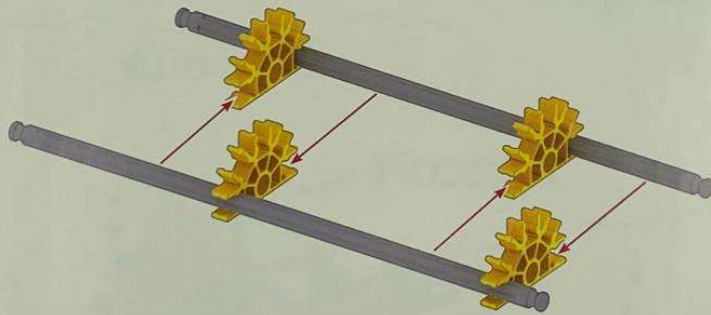
STEP 1

GATHER THESE PIECES:

4



2



SUBMARINE SIZE

Submarines can be massive! In fact, some submarines are as long as two football fields and wider than a three-car lane highway.

STEP 1 2 3 4

建構潛水艇

步驟 1

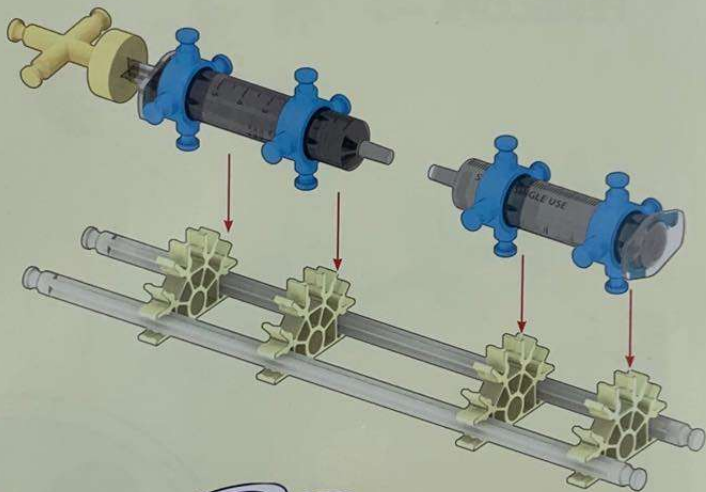
準備以下配件，並照著圖解組裝積木配件

潛水艇的尺寸

潛水艇可以很巨大! 事實上有些巨大的潛水艇長度有如兩座足球場這麼大，而寬度最大則等於有三個高速公路的車道寬。

STEP 2

GATHER THESE PIECES:



The first known military submarine was constructed in 1775. This submarine was called, Turtle.

STEP 1 2 3 4

步驟 2

準備以下配件，並照著圖解組裝積木配件

最早所知的軍事潛艇在 1775 年被建造，而這艘潛艇被取名為「海龜號」。

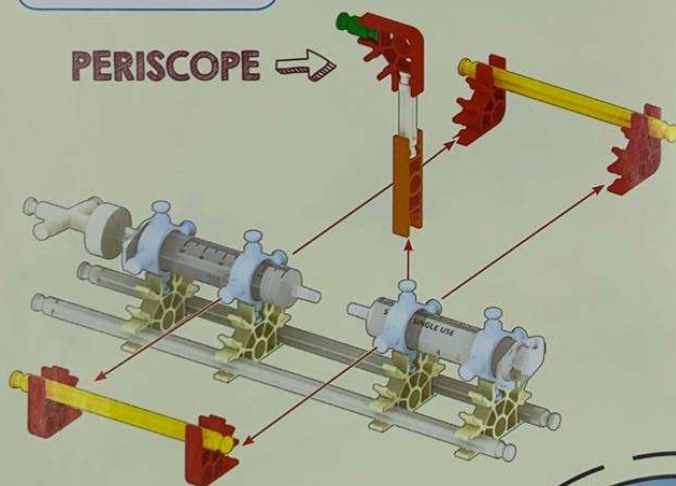
BUILD THE SUBMARINE

STEP 3

GATHER THESE PIECES:



PERISCOPE



THE ROLE OF A PERISCOPE

A periscope helps submarine drivers see above water.



STEP 1 2 3 4

建構潛水艇

步驟 3

準備以下配件，並照著圖解組裝積木配件

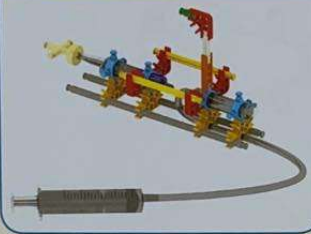
PERISCOPE 潛望鏡

潛望鏡的角色

潛望鏡是用來幫助前在海面下的潛水艇能夠觀察水面上的動態。

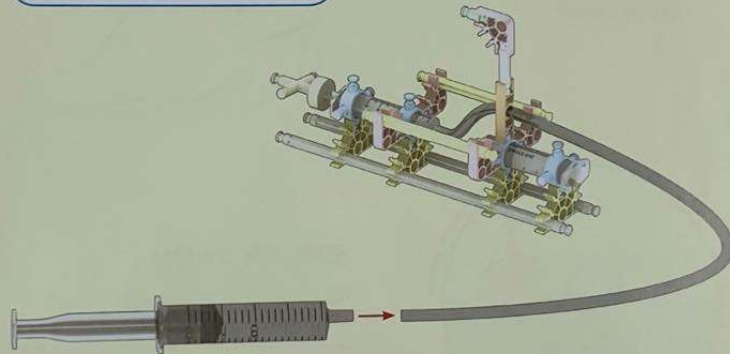
CONNECT THE PUMP

STEP 4



GATHER THESE PIECES:

- 1 20mL Syringe
- 1 Long Tube



By controlling the amount of air in the pump, you can make your underwater vehicle more or less buoyant.

See pages 6-8 for a refresher on how to fill your pump with air and make your model move.

STEP 1 2 3 4

Moving Creations with **k'nex**

hand2mind.com 21

建構潛水艇

步驟 4

準備以下配件，並照著圖解組裝積木配件

藉由控制幫浦內的空氣量，你就能控制潛水艇在水中的深淺位置(浮力)。

可參閱 P5-8 複習一下如何將幫浦充滿氣體以及如何推動模型

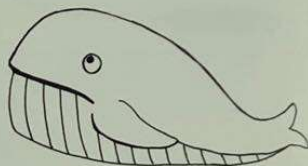
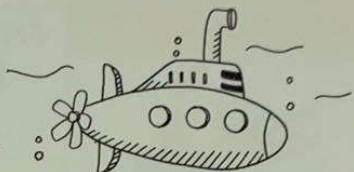
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好玩伴
Good Playmate

IMAGINE!

YOU ARE EXPLORING THE DEEP, DARK SEA...

Through the periscope, you spot a mysterious creature. You sink the submarine to the ocean bottom to keep watch without detection. Suddenly, a giant whale appears. Watch out - it's about to crash into your craft. Quick! Raise the submarine! It's getting closer!



SINK OR SWIM!

Fill a tub, sink, or kiddie pool with water. Place the submarine in the water. Push the pump in to cause the submarine to float to the surface. Pull the pump out to send the submarine under water.

Try this! Experiment with adding different amounts of air to your pump. See what it takes to float at different depths.

想像一下

你正在執行一個探索深海的任務

透過潛望鏡，你發現了一個神祕的生物。此時你將潛水艇潛到海底隱藏著不被發現。突然，有一個非常巨大的鯨魚現身！小心！這隻鯨魚幾乎快要撞到你的潛水艇了！快！我們必須趕快將潛水艇上升！我們越來越接近鯨魚了！

沉下去或在水面航行

找一個浴缸或是家用兒童游泳池注滿水，將你建構好的潛水艇放入水中。推進幫浦時，因為氣體注入潛水艇中，浮力使得潛水艇會浮在水面上。拉起幫浦的拉柄時，氣體從潛水艇中抽回幫浦，又使得潛水艇再次沉入水中！

你可以嘗試將不同量的空氣注入幫浦中，試驗不同量的空氣是否會影響潛水艇沉入水中的深度！

THINK BIGGER!

ARE YOU READY?

Test the idea that a force can change the direction of a moving object.
Use the scientific method as your guide.

Question

What will happen to the submarine when I make waves? Will it move?
Which way will it move?

Predict

I think this will happen: _____

Experiment

Move your submarine underwater. Then make waves in the water. Ask a friend for help, if needed.

Observe & Record

This is what happened: _____

Draw a Conclusion

Waves caused my submarine to _____

Share Results

Way to go! Make sure to tell someone all about it!

進階思考

你準備好了嗎?

利用動力可以改變物體移動方向的原理來思考下面的題目

問題:

當我們在浴缸或泳池裡製造出水波，潛水艇會變得如何呢？它會移動嗎？會朝向什麼方向移動

預測:

我認為會_____

實驗:

將你的潛艇沉入水中，然後製造出水波。有必要的話可以請一位朋友協助你!

發現與紀錄:

實驗結果為_____

得出結論:

水波會造成潛水艇_____

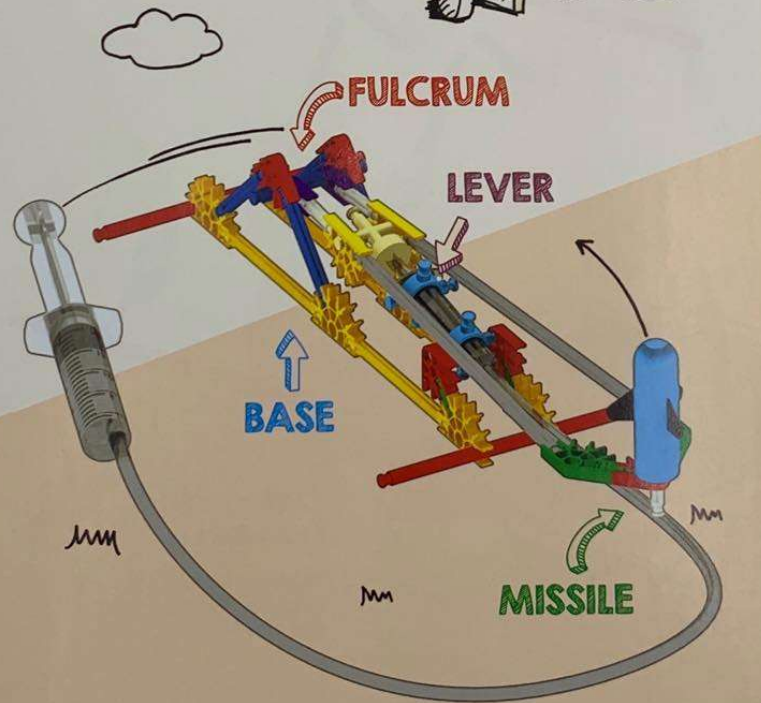
分享成果:

很棒喔！記得要和別人分享你發現的一切！

CATAPULT

LET'S STORM THE CASTLE...

Medieval kingdoms hid behind solid fortresses for protection. But one weapon could take down those walls — a catapult. These heavy lifters could launch rocks, flaming arrows, and more! In this activity, you will build a catapult powered by air.



CATAPULT 投射台.....P25

讓我們來摧毀城堡吧

中世紀的王國都受到堅固的堡壘城牆保護。但有一種武器能夠摧毀這些城牆，也就是投石器台！這些能夠升降的裝置可以發射石塊、燃燒的火箭、以及更多的武器。在這個遊戲活動中，你將學到如何利用氣體動力來建構一座投射台。

FULCRUM 槓桿支點

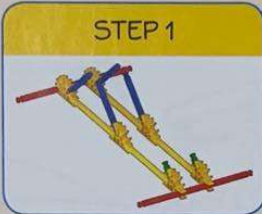
LEVER 槓桿

BASE 基座

MISSILE 飛彈

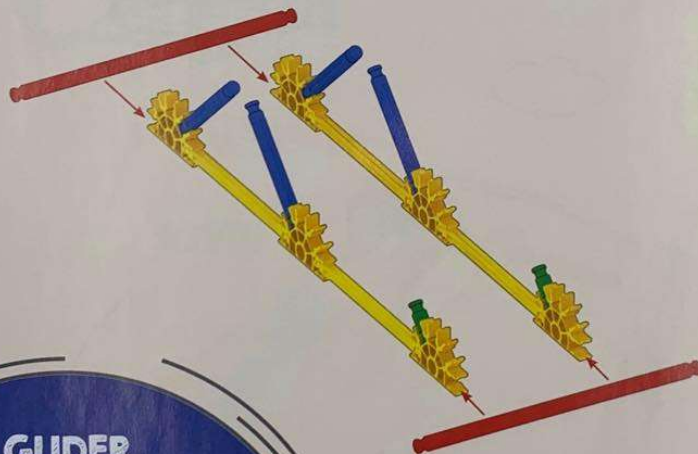
BUILD THE BASE

STEP 1



GATHER THESE PIECES:

- 2
- 4
- 4
- 2
- 6



GLIDER



CATAPULTS IN THE WORLD

Modern catapults are used to launch gliders, aircraft, and missiles.

STEP 1 2 3 4

建構基座

步驟 1

準備以下配件，並照著圖解組裝積木配件

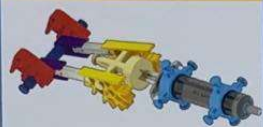
GLIDER 滑翔機

世界上的投射器

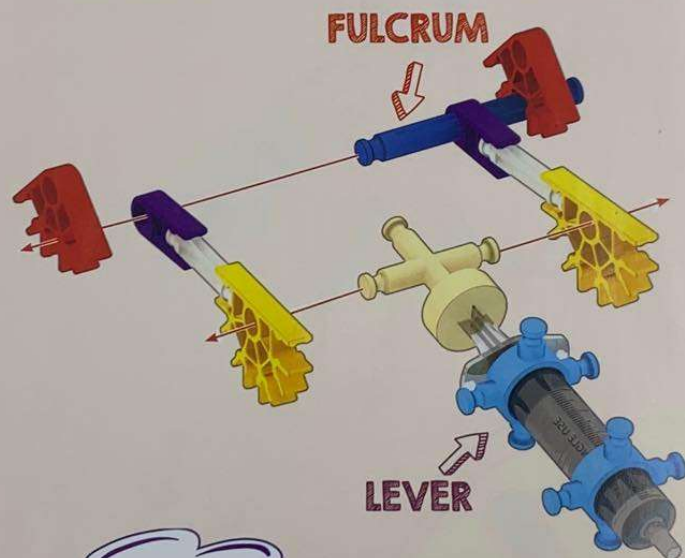
現代的投射器裝置多用來發射滑翔機、飛行器以及飛彈。

BUILD THE LEVER

STEP 2



GATHER THESE PIECES:



FULCRUM

LEVER

A lever is a bar that rests on a point. This point is called a fulcrum. Now it's time to build your lever!

STEP 1 2 3 4

Moving Creations with **k'nex**

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建構槓桿

步驟 2

準備以下配件，並照著圖解組裝積木配件

FULCRUM 槓桿支點

LEVER 槓桿

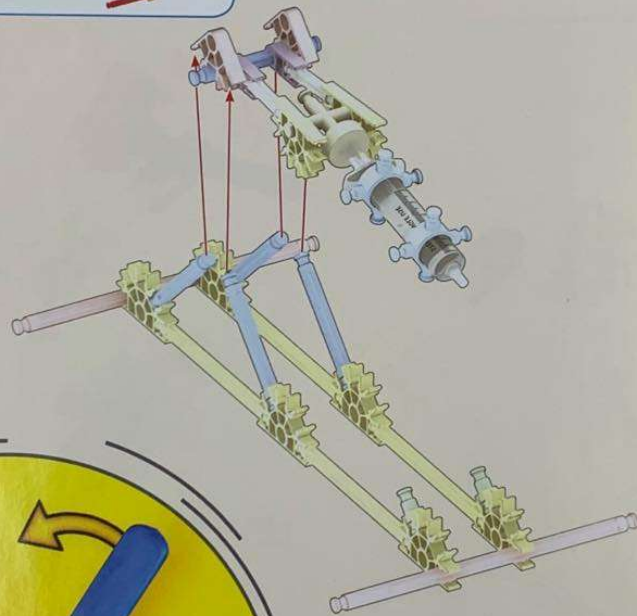
槓桿是置放連結在一個支撐點上的硬棒，這個支撐點稱為槓桿支點，這根硬棒可以繞著支撐點旋轉作動。現在我們就要來建構槓桿支點!

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BUILD THE LEVER

STEP 3



LEVERS AROUND US

A lever is known as a simple machine. When was the last time that you used a lever?

STEP 1 2 3 4

建構槓桿

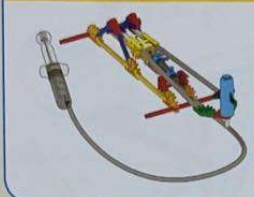
步驟 3

生活中的槓桿應用








槓桿是日常生活中常見的一種機械工具。你記得上一次使用過槓桿工具是什麼時候嗎？

CONNECT THE PARTS

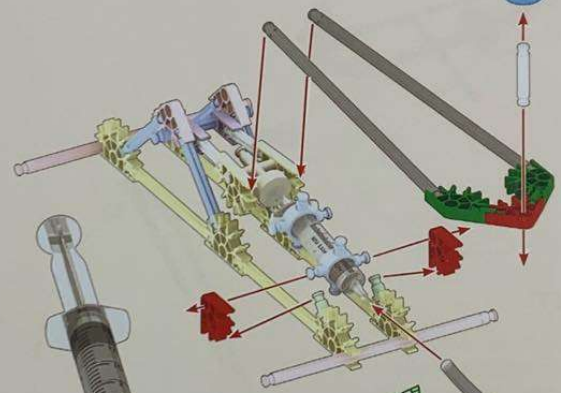
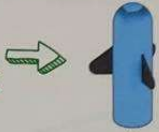
STEP 4



GATHER THESE PIECES:

- 2  3  2  1 
- 2 
- 1  1  20mL
- 1 Short Tube

POSITION THE MISSILE



CONNECT THE PUMP

See pages 6-8 for a refresher on how to fill your pump with air and make your model move.

STEP 1 2 3 4

連結配件

步驟 4

準備以下配件，並照著圖解組裝積木配件

POSITION THE MISSILE 將飛彈(火箭)就定位

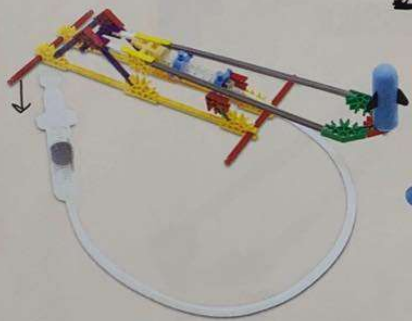
CONNECT THE PUMP 連結幫浦

可參閱 P5-8 複習一下如何將幫浦充滿氣體以及如何推動模型

IMAGINE!

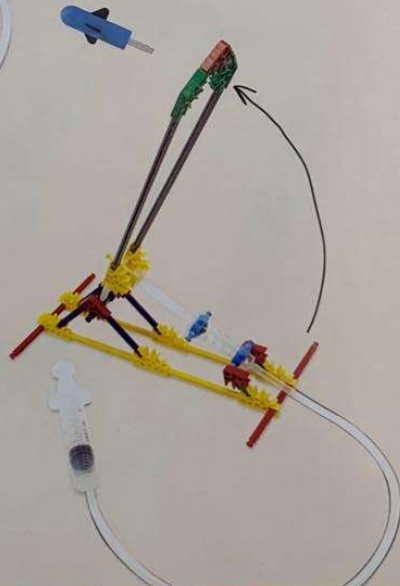
YOU ARE THE SWORN PROTECTOR OF A GREAT CITY...

Inside the fortress ahead of you, enemies are plotting an attack on your kingdom. You set up your catapult and then count down: one, two, three. You launch your weapon and the stones start tumbling down. Summon your army — it's time to go in!



LAUNCH IT!

Push the pump firmly to swing the arm and release the missile. That fortress never had a chance!



Do not aim rocket at eyes or face.

想像一下

你是個勇敢戰士正在保衛你的王國

躲在堡壘裡面的敵人們正在策畫接下的攻擊活動，你必須用飛彈摧毀敵人的基地以保護自己的王國。你已經準備好了投射器，準備攻擊敵人！倒數計時 3, 2, 1! 發射你的飛彈! 很好~敵人城牆已經受損，石塊開始掉落! 集合你的戰友們攻進敵人的堡壘吧!

發射火箭!

確實地推進幫浦讓投射臂舉起發射出飛彈! 敵人將沒有反攻的機會!

注意：發射時請勿將火箭朝向臉或眼睛!

THINK BIGGER!

ARE YOU READY?

1. Launch your missile. Mark where it lands and record your results in the diagram below.
2. Gather more K'NEX® pieces. Add them to your missile, such as in the image shown to the right.
3. Launch your missile again.
4. How far does it fly now? Record your results below.



Record your results.



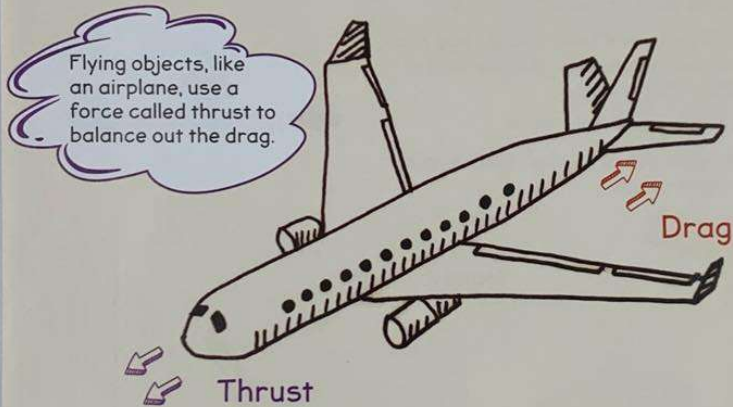
進階思考

你準備好了嗎?

1. 發射你的飛彈，記錄飛彈的著陸點並將其記錄在下面的圖中!
2. 收集更多 K'NEX 配件，用來創造更多不同造型的飛彈(如下圖)
3. 再次發射你的新飛彈
4. 這次飛了多遠呢? 將結果一樣紀錄在下圖中!

THINK BIGGER!

Drag is a force that acts against a flying object. In other words, drag slows down an object flying through the air.



Draw your new rocket design.

WHAT ELSE COULD YOU TRY?

Using various K'NEX® pieces, try adding different sizes and shapes to your missile to experiment with drag. How do the combinations affect how the rocket flies? How it lands? Draw your new rocket design in the space to the right.

進階思考

飛行阻力(Drag)是一種飛行器與空氣摩擦形成的阻力。換句話說，飛行阻力會降低飛行器飛行的速度。

飛行器像是飛機，會利用一種動力叫做推力來平衡飛行中所遇到的飛行阻力。

Drag 飛行阻力

Thrust 飛行推力

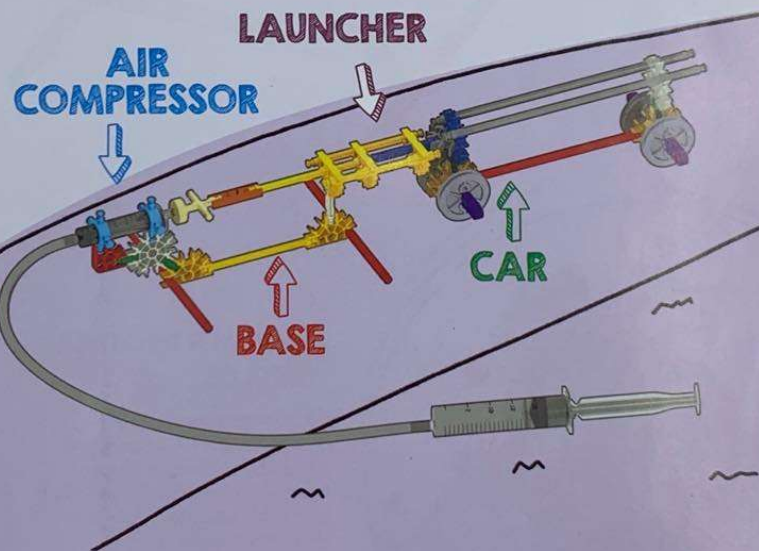
還有什麼實驗遊戲可以嘗試呢?

利用不同的 K'NEX 配件，建造及投射不同尺寸以及形狀的飛彈，試驗不同造型的飛彈(代表有著不同飛行阻力)對火箭飛行以及著陸的影響，哪一種尺寸以及造型能夠有更小的飛行阻力呢? 嘗試在右方空白處畫出你的最佳飛彈新設計!

AIR CAR

LET'S BUILD THE CAR
OF THE FUTURE...

Air cars can zip and zoom
around on pressurized air
molecules. That's right, they run
on **air bubbles**. In this activity,
you will build a car that runs on
air, too!



AIR CAR 空氣動力車.....P33

讓我們來打造一台未來車吧

空氣動力車可以利用壓縮過的氣體分子驅動加速前進! 沒錯! 空氣動力車就是透過氣泡運行! 在這個遊戲活動中, 你將學到如何利用氣體動力來建構一台空氣動力車。

LAUNCHER 發射器

AIR COMPRESSOR 空氣壓縮器

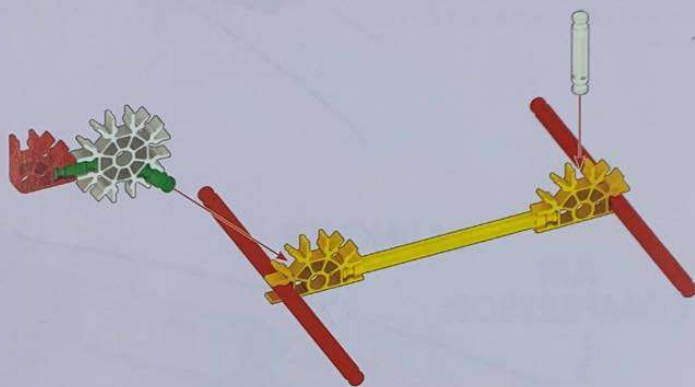
CAR 車體

BASE 基座

BUILD THE BASE

STEP 1

GATHER THESE PIECES:



AIR POWER IN OTHER VEHICLES

Air cars are powered by compressed air. Compressed air has been used to power other vehicles, too. Do you think air can be used to power the motorbike to the left?

STEP 1 2 3 4 5 6 7

建構基座

步驟 1

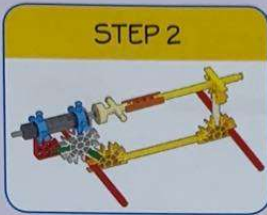
準備以下配件，並照著圖解組裝積木配件

在其他交通工具上的空氣動力

空氣動力車是由壓縮過的氣體所驅動。壓縮過的氣體也能驅動其他的交通工具。思考一下，左圖的摩托車是否也能由空氣動力驅動呢？

BUILD THE LAUNCHER

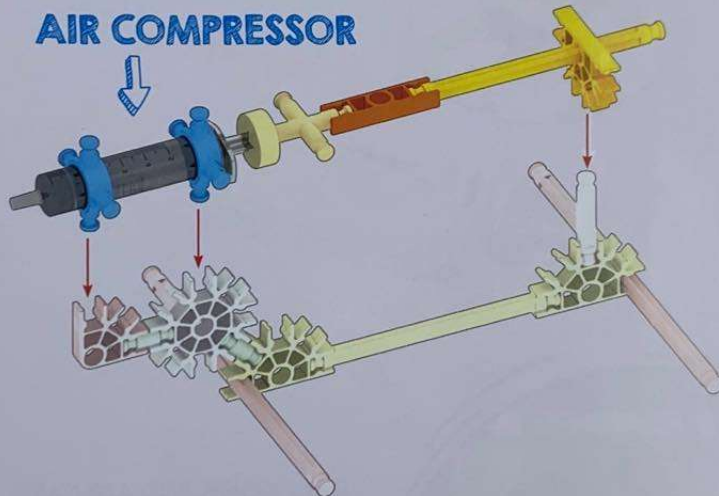
STEP 2



GATHER THESE PIECES:



AIR COMPRESSOR



Instead of a fuel tank,
air cars have built-in
air compressors.

STEP 1 2 3 4 5 6 7

Moving Creations with **knex**

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建構發射器

步驟 2

準備以下配件，並照著圖解組裝積木配件

空氣壓縮器

空氣動力車內建空氣壓縮器，而不是燃油箱。

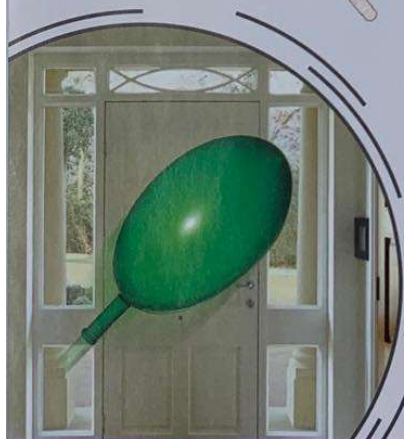
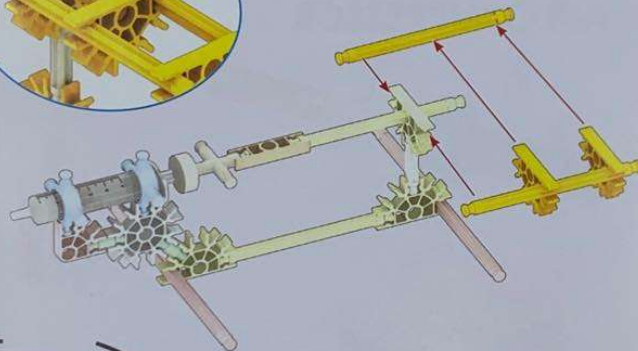
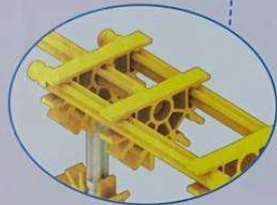
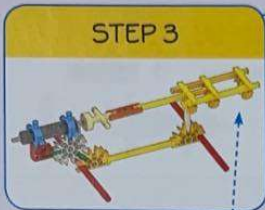
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好玩伴
Good Playmate

BUILD THE LAUNCHER

STEP 3

GATHER THESE PIECES:



BALLOONS AND AIR CARS

Air cars are powered just like balloons. Air pressure can be used to send a balloon flying across a room. In an air car, air is added to the engine. This creates lots of energy. This energy is then used to power the car!

STEP 1 2 3 4 5 6 7

建構發射器

步驟 3

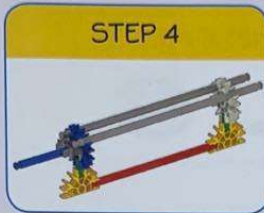
準備以下配件，並照著圖解組裝積木配件

氣球與空氣動力車

空氣動力車就像放開的氣球一樣由空氣動力驅動。在氣球中的空氣壓力從氣球中釋放出來時就會讓放開的氣球在房間裡飛起來。在空氣動力車結構中，空氣動力與引擎相連結。由空氣壓縮器提供足夠的動力能夠驅動車子運行!

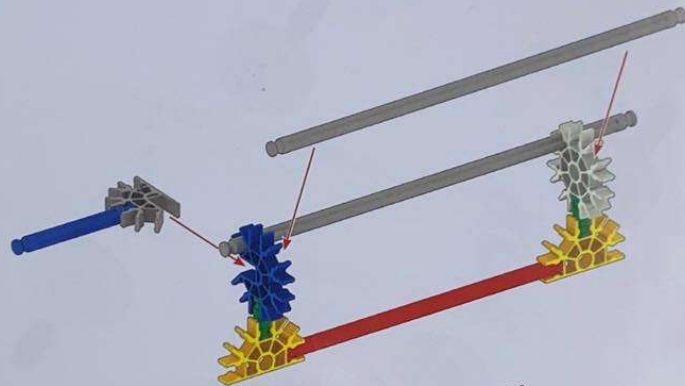
BUILD THE CAR

STEP 4



GATHER THESE PIECES:

- 2 1
- 1
- 2
- 1 2 1 1



HISTORY OF CARS

Regular cars, like the one pictured to the right, were invented in 1885. But did you know that the first air-powered engine was invented in 1896?



STEP 1 2 3 4 5 6 7

Moving Creations with **knex**

hand2mind.com 37

建構車體

步驟 4

準備以下配件，並照著圖解組裝積木配件

車子的歷史

汽車(如右圖)是在 1885 年所發明。但你知道世界上第一個空氣動力引擎在 1896 年發明的嗎?

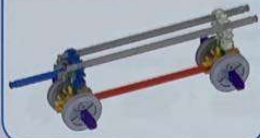
◆請勿任意複製翻印◆ 版權所有：知蘭文化事業有限公司

Hand Playmate
Good Playmate

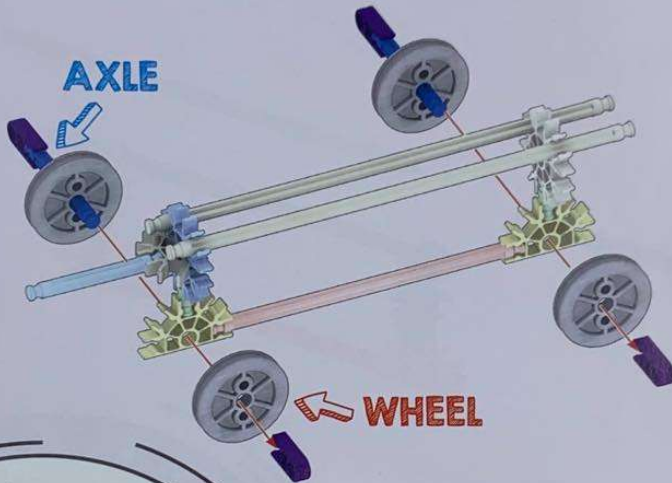
BUILD THE CAR

STEP 5

GATHER THESE PIECES:



AXLE



PENCIL SHARPENERS

Pencil sharpeners are one example of an everyday item that uses a wheel and an axle. What other objects can you think of that use a wheel and an axle?

WHEEL

STEP 1 2 3 4 5 6 7

建構車體

步驟 5

準備以下配件，並照著圖解組裝積木配件

AXLE 車輪軸

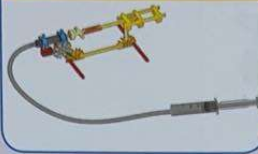
WHEEL 車輪

削鉛筆機

削鉛筆機是我們日常生活中常見應用輪軸裝置的物品之一。你能想得到還有甚麼東西也是運用輪軸裝置的嗎？

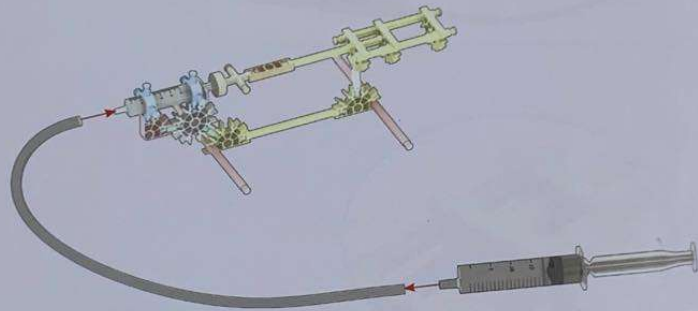
CONNECT THE PUMP

STEP 6



GATHER THESE PIECES:

- 1 20mL Syringe
- 1 Short Tube



Pushing the pump
builds pressure – or
compresses the air inside
the tank.

See pages 6–8
for a refresher
on how to fill your
pump with air
and make your
model move.

STEP 1 2 3 4 5 6 7

連結幫浦

步驟 6

準備以下配件，並照著圖解組裝積木配件

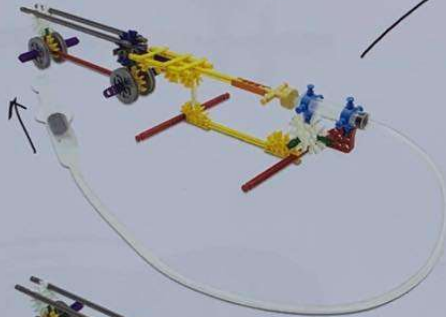
推進幫浦，壓縮幫浦裡的空氣製造出壓力

可參閱 P5-8 複習一下如何將幫浦充滿氣體以及如何推動模型

IMAGINE!

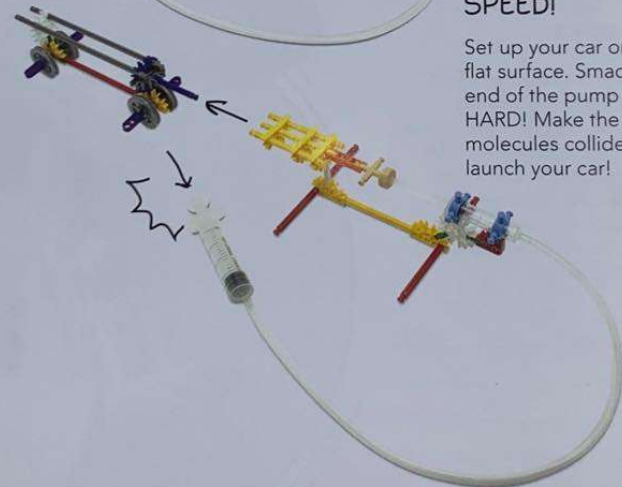
YOU ARE TEST DRIVING YOUR NEW AIR CAR...

Crowds have gathered along the street. Everyone wants to see your creation. Start the engine — it's time to show off!



SPEED!

Set up your car on a flat surface. Smack the end of the pump — HARD! Make the air molecules collide and launch your car!



想像一下

你正在車裡駕駛測試你的新車

街道上充滿了人群。大家都想要觀賞你的最新發明。讓我們發動引擎準備出發秀給大家看!

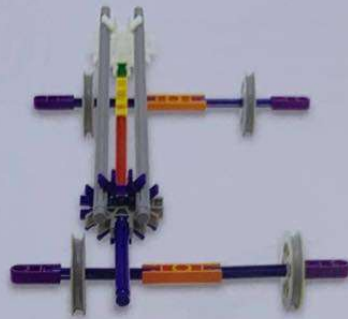
速度

將你的車子放在一個平面上! 快速地用力推進幫浦，讓幫浦瓶內的氣體分子碰撞產生動力! 發射車子吧!

THINK BIGGER!

ARE YOU READY?

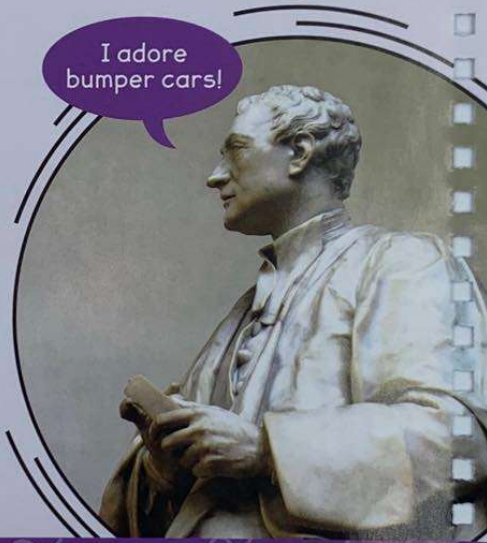
Add K'NEX® pieces to widen your car. Launch the car. Does the wider car move faster or slower? Why? Write your answer below.



WHAT ELSE COULD YOU TRY?

According to Newton's First Law of Motion, a moving object will keep moving unless another force acts on it. Use K'NEX® pieces to create an obstacle course for your air car. Launch the car. What happens when the car bumps into something?

I adore bumper cars!



進階思考

準備好了嗎?

嘗試將其他 K'NEX 配件組裝到你的車上! 如圖所示, 寬度寬一點的車子會跑得快一點還是慢一點呢? 爲什麼呢? 嘗試將你的答案寫在下方吧!

我們還能做那些嘗試呢?

根據牛頓第一運動定律, 除非有其他外力干涉, 一個運動中的物體將會持續移動下去! 利用 K'NEX 配件製作出一些障礙物放置在車道上。再次發射你的空氣動力車, 當車子碰撞上這些障礙物時會發生甚麼事呢?

WHAT IS HYDRAULICS?

When you harness the power of liquids, exciting things happen! What do dentist chairs, car brakes, garbage trucks, and elevators all have in common? That's right, liquids make them move!

Liquids are incompressible — they can't be squished. Think about a full water bottle. What happens when you try to crush it? It doesn't budge! That's because the water molecules inside it don't get any smaller.

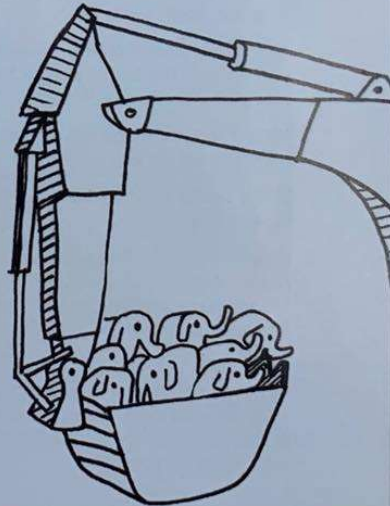


Next, take the cap off. What happens when you squeeze the bottle? Water shoots out of the top! The water molecules are being pushed out of the bottle by your hand. Does this sound similar to a water gun? That's because it is! A water gun works the same way as a squished water bottle.



Now you might be wondering, what would happen if water molecules were compressible? Well, when you squeeze the bottle, the water molecules would squish up into the top of the bottle. A drip or two might spill out but there'd be no splash!

Hydraulic systems are incredibly powerful. In fact, a hydraulic excavator can lift 9,000 tons of earth per hour. That's the same as lifting 1,800 elephants!



什麼是液體動力?

當我們利用液體來控制動作時，就會產生不同的變化！例如牙醫時作的升降診療椅、汽車裡的煞車器、垃圾車的閘門以及電梯，這些機器都有共通的甚麼裝置呢？沒錯！就是液體動力裝置使得這些機器能夠作動！

液體是無法被壓縮的，換句話說，你無法擠壓液體。想像一下有一個裝滿水並封蓋的塑膠瓶，你嘗試擠壓瓶身，會發生甚麼事呢？你幾乎無法擠壓瓶身對吧！這是因為瓶子裡的水分子沒有辦法再變小了。

再來，你將塑膠瓶的蓋子打開，再次擠壓瓶身，會發生甚麼事呢？水從瓶子裡出衝來了對吧！水分子因為你的手擠壓瓶身被推擠出來了！是不是發射水槍時水噴射出來很像呢？其實水槍的運作原理就如同剛剛你做的動作喔！

你現在可能會想，那如果水分子變成是可以壓縮會發生甚麼事呢？假設水分子是可以壓縮的，那剛剛你作的擠壓瓶身動作可能會讓水稍微跑出來個幾滴，但不會像剛剛一樣有大量的水噴出來。

液體動力機械可以擁有非常強大的力量！事實上一台液體動力的挖土機，每小時可以挖起 9000 噸重的土石，等同於舉起 1800 隻的大象喔！

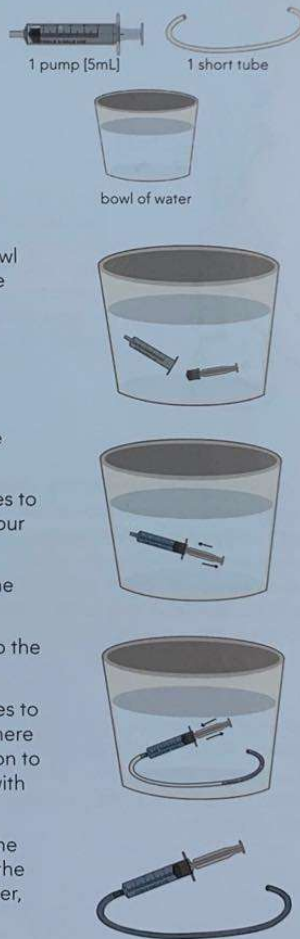
HYDRAULICS CRASH COURSE

Now it's time to become a Master of Hydraulics. You will get everyday water to do wondrous things. Are you ready to get started? Put on your splash gear, because it's time to jump in!

SMALL HYDRAULIC SYSTEM

The hardest part of building a hydraulic system is filling the pumps and tubes with water. So let's practice! You may want to try this a few times or ask an adult for help if you get stuck. Don't worry if you can't get this right on the first try. It's not easy! Practice creating the small hydraulic system until you get the hang of it.

1. Fill a bowl or sink with water. Your bowl should be big enough to fit the entire tube and pump.
2. Detach the piston from the pump.
3. Place the pump and piston fully underwater.
4. Insert the piston into the pump while they are underwater.
5. Close and open the pump a few times to push the air out of the pump. Now your pump should be full of water!
6. Place the tube in the bowl or sink. The tube should be fully under water.
7. While under water, attach the tube to the open pump.
8. Close and open the pump a few times to push the air out of the tube. When there are no more bubbles, move the piston to the open position to fill the system with water.
9. Remove your tube and pump from the water bowl. You're done! Now both the pump and tube should be full of water, with no air bubbles.



快速認識液體動力學

在開始進行建構積木遊戲之前，你必須先清楚了解氣體動力科學！你將會使用日常生活中看似普通的水來進行超好玩的實驗遊戲。你準備好要開始了嗎？

建置一個小型的液體動力系統

建置液體動力系統最困難的部分在於將幫浦與管子內注滿水，所以讓我們先開始練習這個部分。一開始嘗試沒有成功別感到灰心！因為這本來就有困難！如果過程中遇到困難，你可以多嘗試幾次或是請大人們協助。經過幾次練習後你就會越來越上手！

1. 在大碗或是水槽中注入水，水的高度要足夠讓你準備的配件們可以沉到水中。
2. 將幫浦柄(活塞)與幫浦分離。
3. 將幫浦柄(活塞)與幫浦沉到水中。
4. 在水中將幫浦柄(活塞)塞入幫浦中。
5. 在水中將幫浦來回推拉(開啟/關閉)幾次將幫浦內的空氣擠出。現在你的幫浦已經充滿水了！
6. 將管子完全沉到水中。
7. 在水中將管子接上開啟(拉開狀態)的幫浦。
8. 在水中將幫浦來回推拉(開啟/關閉)幾次將管子內的空氣擠出。當管子內沒有氣泡後，將幫浦開啟(拉開狀態)讓幫浦內注滿水。
9. 將幫浦與管子從水裡拿起來！完成！現在的幫浦與管子內應該都充滿了水並沒有氣泡！

What happens when you turn your system upside down? Position the system so the free end of the tube is facing the bowl. What do you notice?

The water stays in the tube! It is defying gravity!

The water stays in the tube because the air pressure is stronger than the weight of the water. In other words, the air is pushing up against the water and keeping it in the tube.



MOVE THE PUMPS



1. Re-create your small hydraulic system from before.
2. Put the loose 5mL pump in a closed position and attach it to the open end of the tube.



What happens when you try to open the closed pump? The other pump closes! This happens because liquid is not compressible. You are simply pushing the liquid from one pump to the other. You just harnessed the power of water!



Now you're ready to dive into building hydraulic systems!

試著將你剛剛建置好的液體動力系統顛倒過來拿著，管子朝下對著大碗或水槽放開自然朝下(如右圖)。你發現了嗎？

水依然在管子內沒有流下來！違反了地球重力法則。

這是因為目前環境中的氣壓比水的重量還要大。換句話說，目前空氣推向水的壓力比水往下的重力還要大，因此氣壓撐著管子裡的水不會落下來！

讓幫浦作動

1. 重新製作一個小型的液壓動力系統。
2. 將一個 5ml 幫浦操作在關閉(推進幫浦柄)的位置，並將其與液壓動力系統管子的另一端連結。

現在你可以嘗試開啟(拉開幫浦柄)剛才那個關閉的幫浦，會發生甚麼事呢？另一端的幫浦關閉了對嗎？這是因為液體是無法被壓縮的。你剛剛開啟幫浦的動作擠壓系統裡的水，讓水被推向另一端的幫浦。恭喜你剛剛完成了讓液體動力系統作動的操作！

現在你已經準備好可以進行建構液體動力工程的遊戲嘍！

HYDRAULICS TROUBLESHOOTING

It may take some trial and error to make your hydraulic systems run smoothly. Sometimes too much pressure can build up in the system and the tubes can pop off. But fear not, we've got some tips for you here. As you go, make sure your pumps are positioned on the K'NEX® pieces exactly as shown. If you get stuck while building your model, come back here for some help.

COLORING THE WATER

Some hydraulic models are shown with colored water. If you want to color your water too, just add a few drops of food coloring! Be careful when you use food coloring though - it can stain!

HOW TO FILL THE LONG TUBE WITH WATER

Use the 20mL pump to fill the long tube with water. Follow the same steps as in the Small Hydraulic System on page 48. Don't worry if you can't get the tube completely full of water — your system should still move.

THERE ARE AIR BUBBLES IN MY SYSTEM

Don't worry if there are air bubbles in your system. Sometimes this will happen! The air bubbles should not affect your model.

WHERE DO I SET UP MY HYDRAULIC SYSTEM?

Think about building your hydraulic models outside, in a kitchen, or a bathroom. Make sure to have some towels around.

HOW DO I TAKE APART MY HYDRAULIC SYSTEM?

Follow these steps to take apart your hydraulic system:

1. Put the loose pump in an open position.
2. Detach the tube from the fixed pump.
3. Detach the tube from the loose pump over a sink or bowl. Now dump out the water!

關於液體動力裝置的故障排除

有些時候要製造一個液體動力裝置需要來回多次的失敗與嘗試，有些時候系統裡的壓力會過大操作時使得管子脫落。沒關係！這裡我們會提供你一些建置操作小技巧。當你在操作液體動力部分的積木遊戲時，要確認幫浦與 K'NEX 配件連結的位置都與說明書上圖示相符。如果在建構的過程中卡住或遇到問題，可以回到這頁找尋可能的解決方案。

將水染色

有許多液體動力裝置都會以有顏色的液體來呈現。如果你也想要將水染色，可以在水中加入幾滴食用染色劑。

如何將長管注滿水？

可以參考 P48 的小型液體動力系統建置步驟。如果沒有辦法百分之百的將長管注滿水沒關係，管子裡有些許氣泡還是能進行操作的！

液體動力系統內有氣泡？

別擔心。裝置內有些許氣泡是很常見的情況，應該不會影響你的動力工程模型作動！

我應該在哪裡進行建構與操作遊戲呢？

建議在廚房或是浴室的空間，在一旁可以準備毛巾可隨時擦拭潑濺出來的水。

要如何移除液體動力裝置？

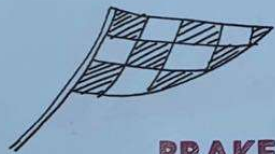
請參考以下步驟：

1. 將較鬆的幫浦操作至開啟位置
2. 將管子從另一端的幫浦移除
3. 在大碗或水槽上方將管子完全移除，將水倒出來。

BRAKE

LET'S HIT THE RACETRACK...

Getting around an oval racetrack requires expert braking skills. One wrong move and your racecar could lose control. In this activity, you will build a hydraulic brake made to win!

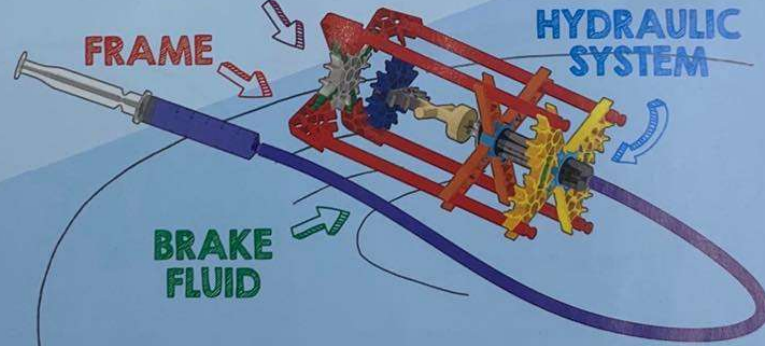


BRAKE PAD

FRAME

HYDRAULIC SYSTEM

BRAKE FLUID



BRAKE 煞車系統.....P47

讓我們來到賽車場

在橢圓形的賽車場賽車，需要高超的駕駛與剎車技術！一個不小心就很有可能造成車子失控！在這個遊戲活動中，你將學到如何利用液體動力來建構一個煞車系統來取得賽車勝利。

BRAKE PAD 煞車片

FRAME 框架

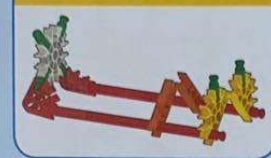
HYDRAULIC SYSTEM 液體動力裝置

BRAKE 煞車液

BUILD THE FRAME

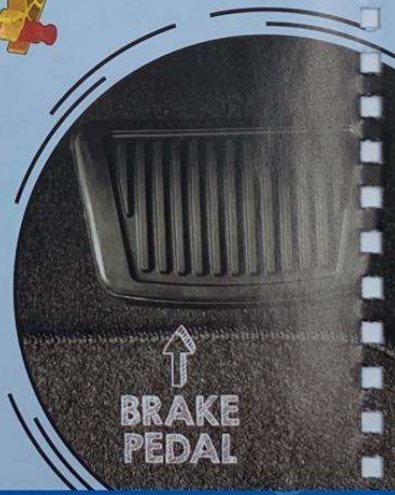
STEP 1

GATHER THESE PIECES:



BRAKE PEDALS

Every car has a brake pedal below the steering wheel. The brake pedal activates the brake system when it is pressed.



STEP 1 2 3 4

建構框架

步驟 1

準備以下配件，並照著圖解組裝積木配件

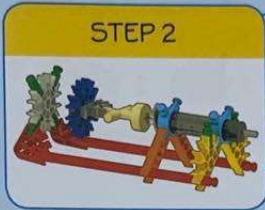
煞車踏板

每台汽車上在方向盤下方都有一個煞車踏板。當踩壓這個煞車踏板時將會啟動煞車系統!

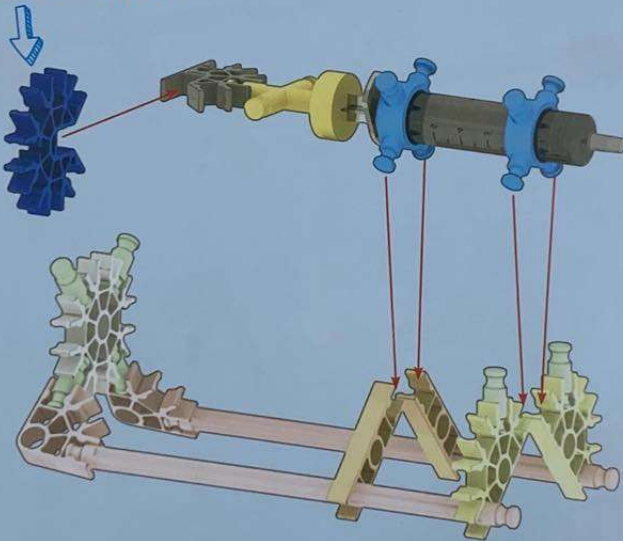
BUILD THE BRAKE PAD

STEP 2

GATHER THESE PIECES:



BRAKE PAD



Do you know how a brake pad stops a moving car?
It's simple! It just pushes up against part of the wheel.
This causes the wheel to stop moving and the car to stop.

STEP 1 2 3 4

Moving Creations with **knex**

hand2mind.com 49

建構煞車片

步驟 2

準備以下配件，並照著圖解組裝積木配件

煞車片

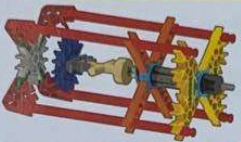
你知道行駛中的車子是如何由煞車片運作而停下來嗎？非常簡單！也就是踩剎車時煞車片升起與車輪上的煞車碟摩擦，讓車輪慢慢減少運轉最後車子停下。

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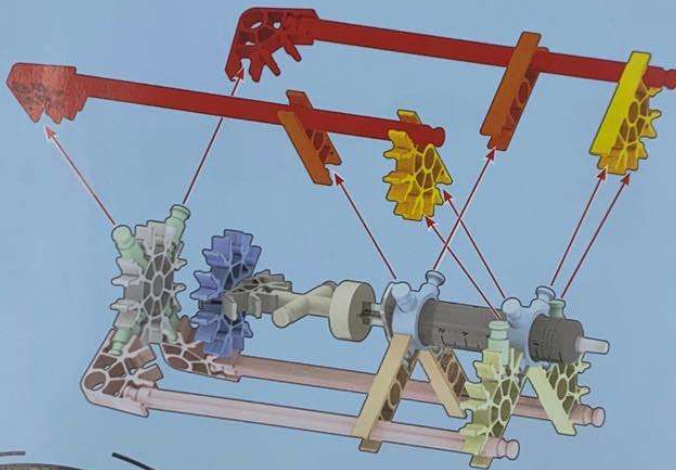
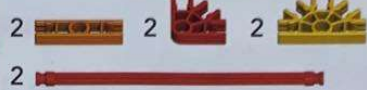
好玩伴
Good Playmate

CONNECT THE PARTS

STEP 3



GATHER THESE PIECES:



DUESENBERG

The first passenger car to use a hydraulic brake was a Duesenberg. This happened in 1921!

STEP 1 2 3 4

連結配件

步驟 3

準備以下配件，並照著圖解組裝積木配件

DUESENBERG 杜森堡

第一個使用液壓動力煞車系統的客車為 DUESENBERG 杜森堡品牌的汽車，時間在 1921 年!

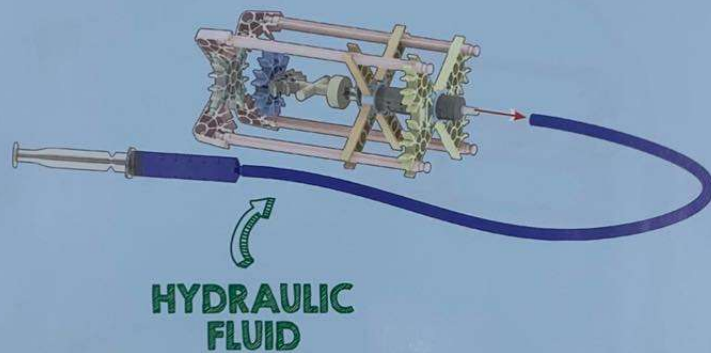
ADD THE HYDRAULICS

STEP 4



GATHER THESE PIECES:

- 1  5mL
- 1 Short Tube



See pages 44-46
for a refresher on
how to fill up the
pump with water.

Brakes depend on
friction to work. Friction
is the force that works
against energy in motion.

STEP 1 2 3 4

Moving Creations with **k'nex**

hand2mind.com 51

加上液壓系統

步驟 4

準備以下配件，並照著圖解組裝積木配件

液壓液體

可參閱 P44-46 複習一下如何將幫浦充滿水

煞車系統必須仰賴摩擦力來運作！摩擦力是一種用來抵銷物體移動中動能的力量！

◆請勿任意複製翻印◆ 版權所有：知蘭文化事業有限公司

Good Playmate

IMAGINE!

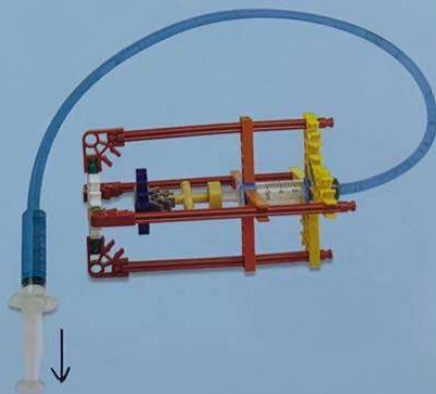
YOU ARE SPEEDING ALONG
THE RACETRACK ...

Here comes the first bend of the track. Hit the brakes and take the turn. Phew — you're still on course. Get ready for the next one!



SQUEEEEEEEZE!

Completely push in the pump to close the brake. It's just like you're pushing on a brake pedal. Pull out the pump again to open the brake. You did it!



想像一下

你正在賽車場上競速

現在來到了賽道上第一個彎道，準備踩煞車並且轉彎！啾~成功了！你還維持在賽道上！準備好下一個彎道吧！

擠~~~~壓！

將幫浦完全退進關閉煞車器，就像在踩煞車板一樣！再拉起幫浦柄開啟煞車器！你成功做到嘍！

THINK BIGGER!

ARE YOU READY?

Balance a K'NEX® piece inside your open brake. Push in the pump to close the brake. What's different? How much harder did you have to push?



Does the added piece increase or decrease friction?

PIT CREW RACERS

A racecar's pit crew are speed demons, too. They have only seconds to make repairs — and get the car back in the race!



進階思考

準備好了嗎?

再開啟中的煞車器中放入一個 K'NEX 配件(如圖)，然後推進幫浦以關閉煞車器。有發現甚麼差異嗎? 你用了多大的力氣推進幫浦呢?

放入的配件增加還是減少了摩擦力呢?

賽車維修人員

在賽道上的維修人員們也是速度狂人! 他們只有幾秒鐘的時間可以進行維修替換零件，處理完成就要馬上讓賽車再次回到賽道上!

THINK BIGGER!

WHAT ELSE COULD YOU TRY?

Take out the top green pieces on the back of your brake frame. How do you think this will affect your hydraulic brake? Write your prediction below.



Now, push your brake against the back of the frame. What do you notice? How do unbalanced forces affect this experiment?

An unbalanced force means that the pushes and pulles in a system are not equal.

進階思考

我們還能進行甚麼樣的嘗試呢？

嘗試將煞車系統上的綠色配件移除！你覺得這會對你的液壓煞車系統產生甚麼影響呢？將你的預測寫下來！

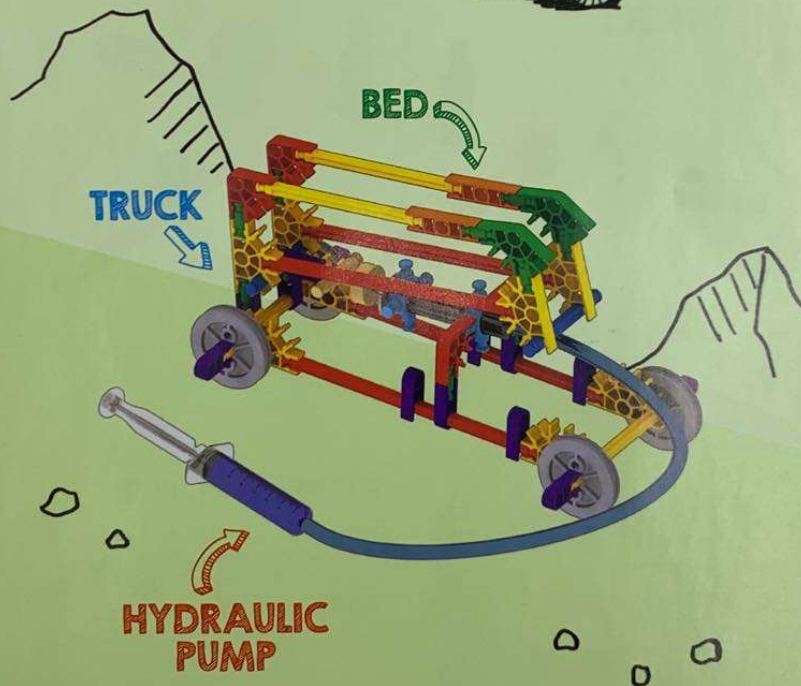
現在，嘗試推進幫浦！你發現了甚麼呢？不平衡的力量如何影響這個嘗試呢？

不平衡的力量代表著在這個系統之中推進與拉回的力量是不平均的。

DUMP TRUCK

LET'S STRIKE GOLD...

Dump trucks are important helpers at any gold mine. Their job is to carry around tons of golden ore. With powerful lifting abilities, no load is too big. In this activity, you'll build a truck that lifts and dumps because of hydraulics.



DUMP TRUCK 砂石車.....P55

讓我們來掏金吧

工程砂石車在各個金礦工程區都扮演了重要的角色。它們的主要任務為載運好幾噸重的金礦砂石。特點是有著強力的舉臂能夠撐起車斗，再重的砂石都能撐起! 在這個遊戲活動中，你將學到如何利用液體動力來建構一個砂石工程車，能夠伸縮舉臂升降車斗。

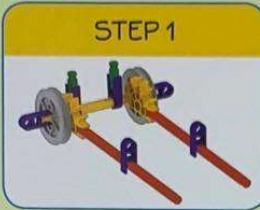
BED 車斗

TRUCK 車體

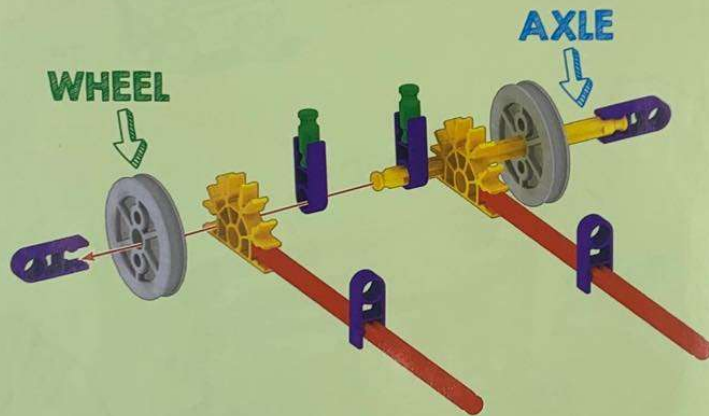
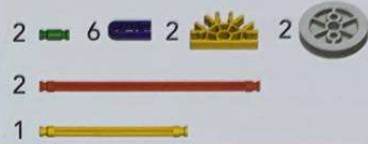
HYDRAULIC PUMP 液壓動力系統

BUILD THE TRUCK

STEP 1



GATHER THESE PIECES:



A SIMPLE MACHINE

A dump truck's wheel and axle is a kind of simple machine. Its rolling motion helps the truck move heavy loads.

STEP 1 2 3 4 5 6

建構車體

步驟 1

準備以下配件，並照著圖解組裝積木配件

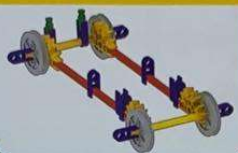
AXLE 輪軸

WHEEL 輪子

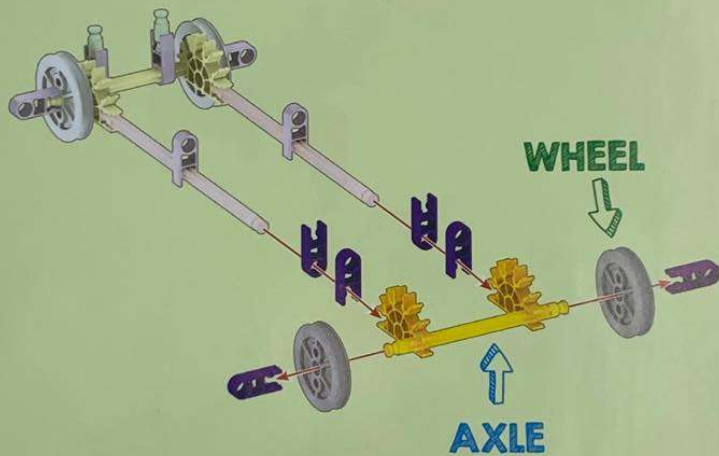
簡單的機械

砂石工程車的輪子與輪軸是一種簡單的機械裝置。輪軸帶動輪子轉動的動作讓砂石工程車能夠載運重物移動!

STEP 2



GATHER THESE PIECES:



The world's biggest dump truck is as long as two double-decker buses. And it weighs more than an airplane!

STEP 1 2 3 4 5 6

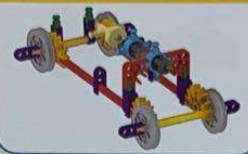
步驟 2

準備以下配件，並照著圖解組裝積木配件

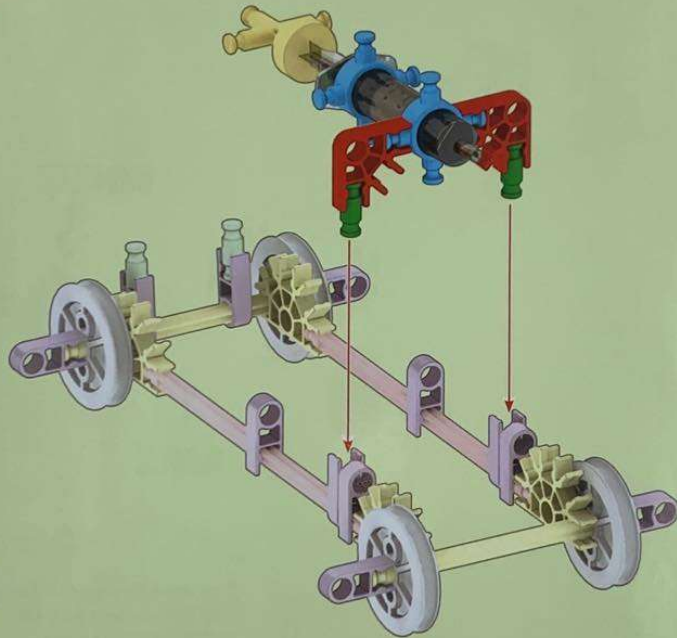
世界上最大的工程砂石車長度約雙層巴士的兩倍長，而且重量比一台飛機還要重！

ADD THE PUMP

STEP 3



GATHER THESE PIECES:



STEP 1 2 3 4 5 6

連結幫浦

步驟 3

準備以下配件，並照著圖解組裝積木配件

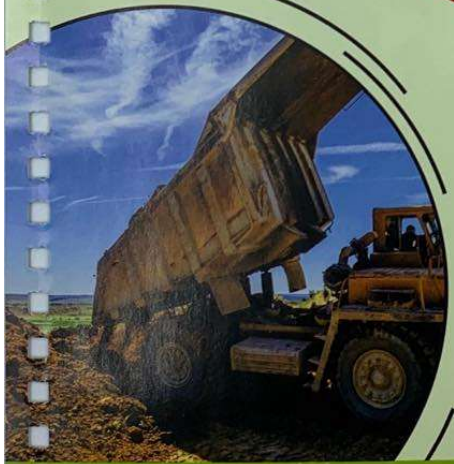
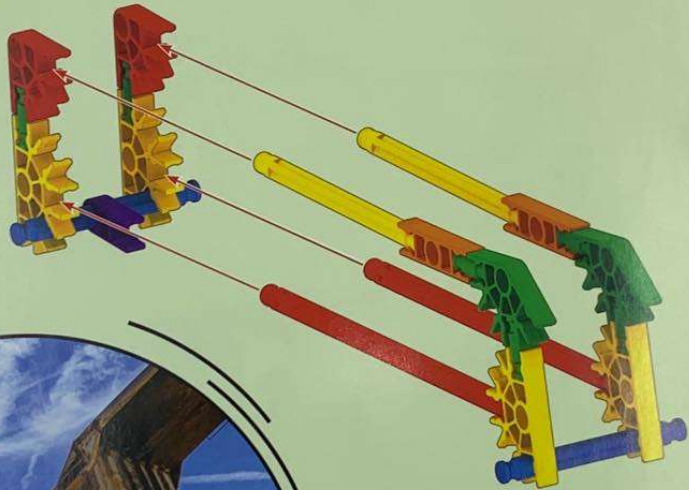
BUILD THE BED

STEP 4



GATHER THESE PIECES:

- 2 2 2 4
- 1 6 2
- 2 2



GEOMETRY OF DUMP TRUCKS

The angle of the lifted bed makes it easier to drop the truck's heavy load.

STEP 1 2 3 4 5 6

建構車斗

步驟 4

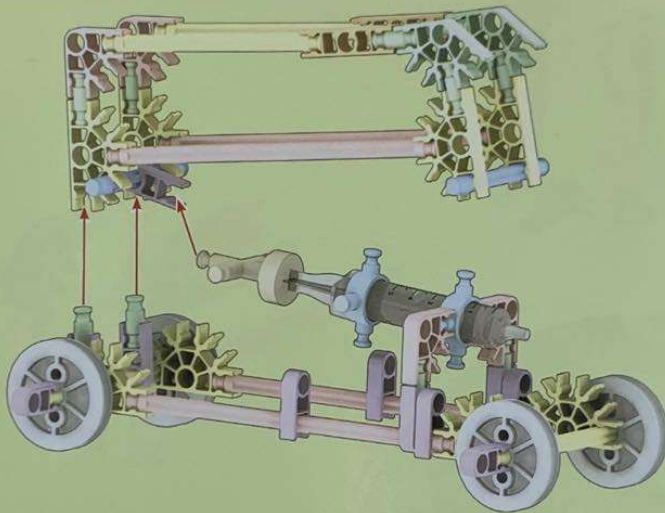
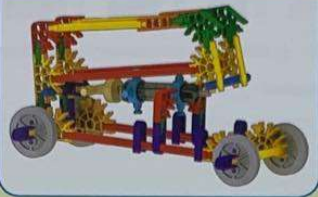
準備以下配件，並照著圖解組裝積木配件

砂石工程車的幾何學

砂石工程車車斗設計舉起的角度能夠讓車子能夠輕鬆地將很重的砂石倒下。

CONNECT THE PARTS

STEP 5



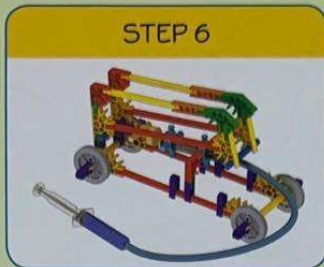
STEP 1 2 3 4 5 6

連結配件


步驟 5

ADD THE HYDRAULICS

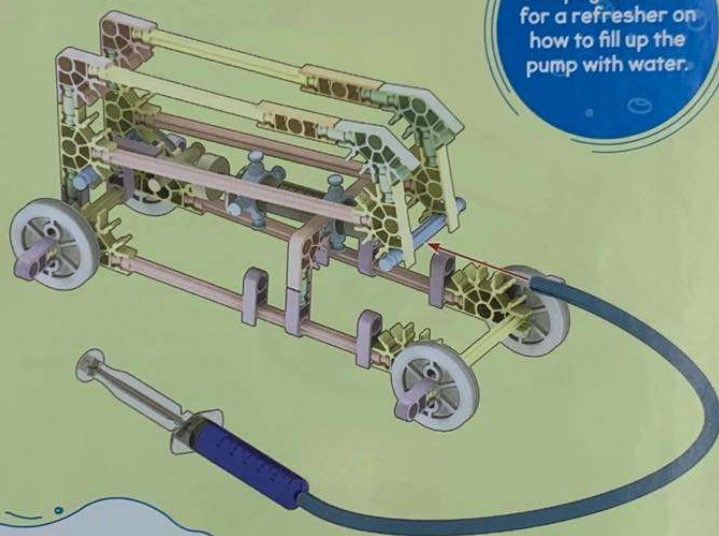
STEP 6



GATHER THESE PIECES:

- 1  5mL
- 1 Short Tube

See pages 44-46
for a refresher on
how to fill up the
pump with water.



Pressure inside the
dump truck's pump
will raise and lower
the truck bed.

STEP 1 2 3 4 5 6

Moving Creations with **k'nex**

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連結液體壓力系統

步驟 6

準備以下配件，並照著圖解組裝積木配件

可參閱 P44-46 複習一下如何將幫浦充滿水

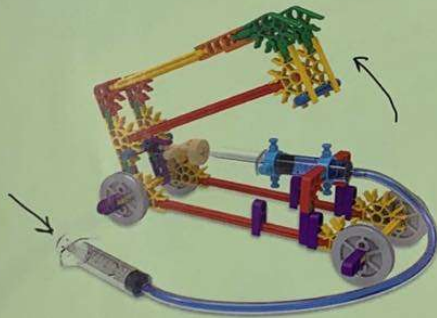
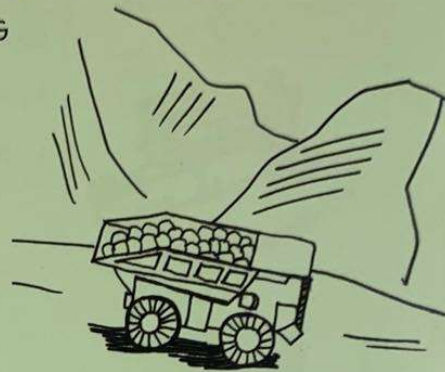
在車內幫浦裡的液體壓力能夠使得舉臂作動將車斗升起或下降。

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IMAGINE!

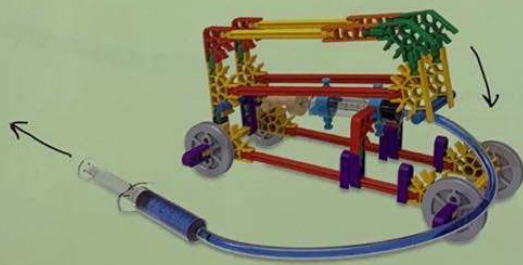
YOU'VE BEEN WORKING IN A GOLD MINE...

The back of your truck is heavy with valuable ore. You take this special cargo to a processing plant. You'll dump the ore, and workers will separate the gold from rocks. Now you'll head back to the mine. There's more gold to find!



DUMP IT!

Push the pump completely in to lift the truck bed. When you pull the pump out again, the bed will lower back down.



想像一下

你正在一個金礦區工作

你駕駛的工程車後面載著非常重、價值非凡的金礦沙，你正要將工程車開往處理礦砂的機器。你將礦砂倒下後，其他工人會將金礦從砂石中篩選分離出來。然後你準備再次回到礦區，載運更多的金礦砂回來!

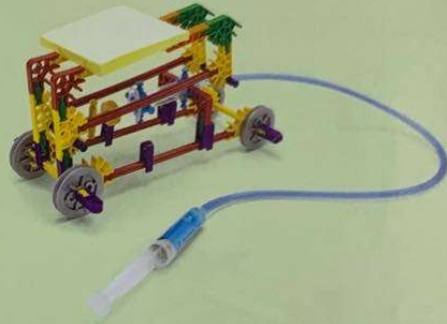
傾倒砂石

推進幫浦到底來升起車斗。然後再次拉回幫浦拉柄，車斗又再次下降回原位置。

THINK BIGGER!

ARE YOU READY?

Experiment with different weights on top of your truck bed. Try lifting extra K'NEX® pieces, a pad of sticky notes, a napkin, a ruler, and a plastic spoon. How does the truck's lifting ability change with different weights? Rank your results.



Object	Ease of lifting
	Easiest
	Easy
	Somewhere in the middle
	Harder
	Hardest

Dumping the truck bed is an example of a force that pushes an object.

進階思考

你準備好了嗎?

我們可以嘗試在車斗上放上不同的重量，例如我們可以放上幾個多的 K'NEX 配件、一本便利貼、一條領巾、或是一隻塑膠湯匙。觀察車斗在升降過程中是否因為載運的重量不同而有差異呢？試著在下方表格填入你的排名

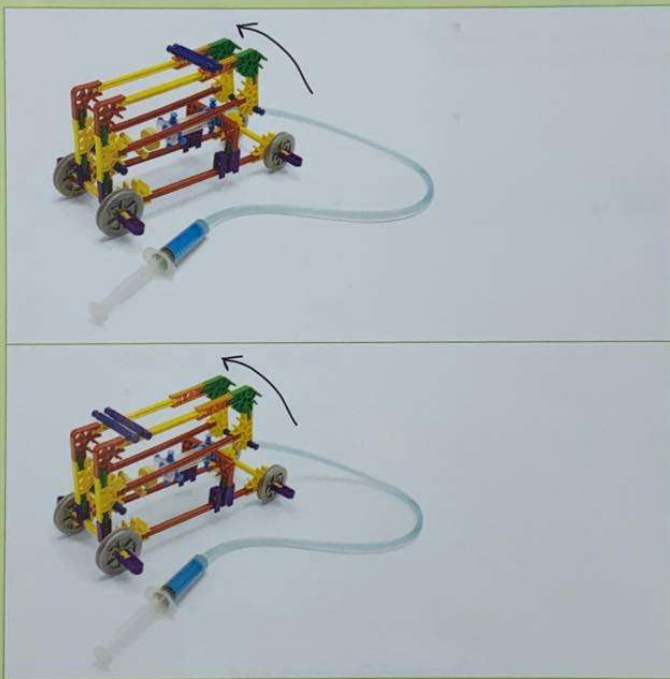
放置物體	升降的容易程度
	最簡單
	簡單
	中等
	困難
	最困難

將車斗升起傾倒物品就是一種使用推力的例子。

THINK BIGGER!

WHAT ELSE COULD YOU TRY?

Balance two blue K'NEX® rods on the back end of the truck bed. Dump them. Where do the rods land? Now place the rods on the front end of the truck bed. Dump them again. Where do the rods land now? Record your results below.



進階思考

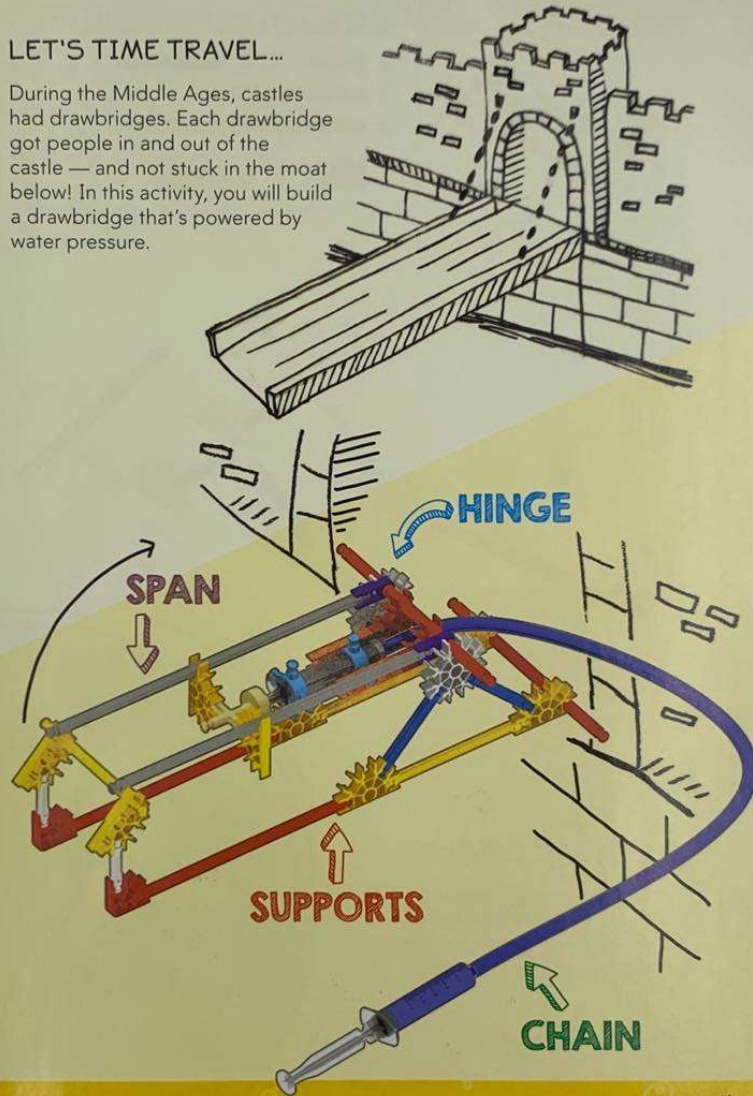
我們還可以做甚麼不一樣的嘗試呢?

將兩根藍色的 K'NEX 配件桿平衡地放在車斗尾部，然後作傾倒的動作，觀察配件桿移動到哪裡去了呢？現在再將兩根藍色 K'NEX 配件桿平衡地放在車斗前方部分，然後作傾倒的動作，觀察配件桿又移動到哪裡去了呢？將你的紀錄寫在下方圖空白處！

DRAWBRIDGE

LET'S TIME TRAVEL...

During the Middle Ages, castles had drawbridges. Each drawbridge got people in and out of the castle — and not stuck in the moat below! In this activity, you will build a drawbridge that's powered by water pressure.



DRAWBRIDGE 升降橋.....P65

讓我們進入時空旅行

在中世紀的時候，城堡都配置有升降橋，提供城堡內的居民進出使用，而不會被護城河給阻擋了。在這個遊戲活動中，你將學到如何利用液體動力來建構一個升降橋裝置！

HINGE 鉸鏈裝置

SPAN 跨橋

SUPPORTS 支撐裝置

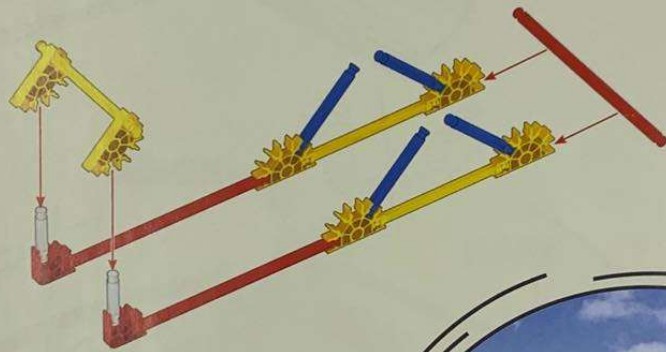
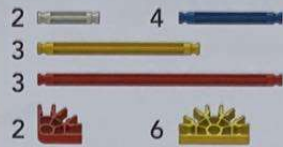
CHAIN 鎖鏈(液體動力裝置)

BUILD THE SUPPORTS

STEP 1



GATHER THESE PIECES:



MOATS AND CASTLES

A moat is a wide ditch, usually filled with water. Did you know that some castle owners added fish to their moat? Catch that!

STEP 1 2 3 4 5 6 7



建構支撐裝置

步驟 1

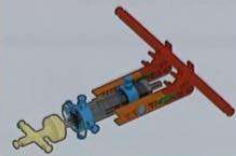
準備以下配件，並照著圖解組裝積木配件

護城河與城堡

護城河是建在城堡外圍很深的溝渠，通常都會注滿水。你知道有些城堡主人會在護城河內養魚嗎？下次試著觀察看看！

BUILD THE HINGE

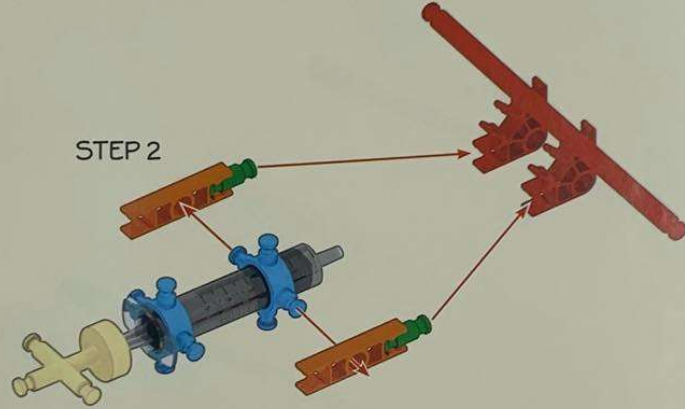
STEPS 2-3



GATHER THESE PIECES:



STEP 3



A hinge is a joint which connects two different objects. The hinge lets the two objects rotate and swing. Hinges are all around us! Check out the nearest door - can you spot the hinge?

STEP 1 2 3 4 5 6 7

Moving Creations with **k'nex**

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建構鉸鍊裝置

步驟 2-3

準備以下配件，並照著圖解組裝積木配件

鉸鏈裝置是一種連結連接兩個固體的組合裝置，可以使兩者之間做轉動擺動的機械裝置。鉸鏈裝置常見於我們的日常生活中，找到離你最近的一扇門，試著找找看鉸鏈裝置在哪呢？

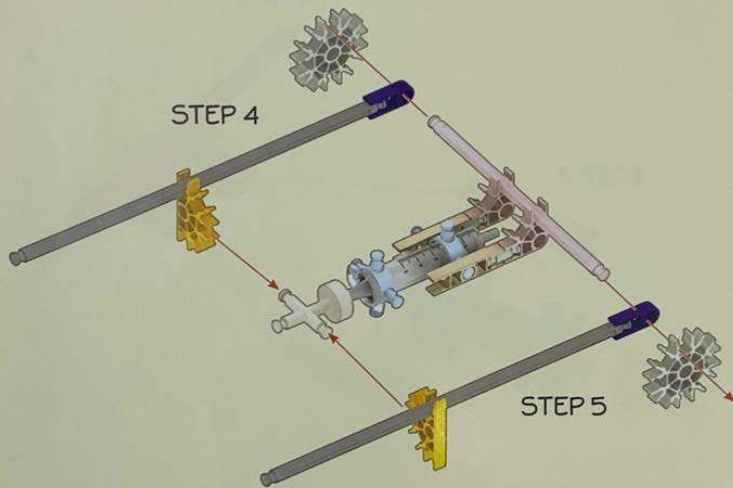
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Hand Playmate
Good Playmate

BUILD THE SPAN

STEPS 4-5

GATHER THESE PIECES:



A modern movable bridge works just like the medieval drawbridge. Parts of the road lift or swing so traveling boats can pass under the bridge.

STEP 1 2 3 4 5 6 7

建構跨橋

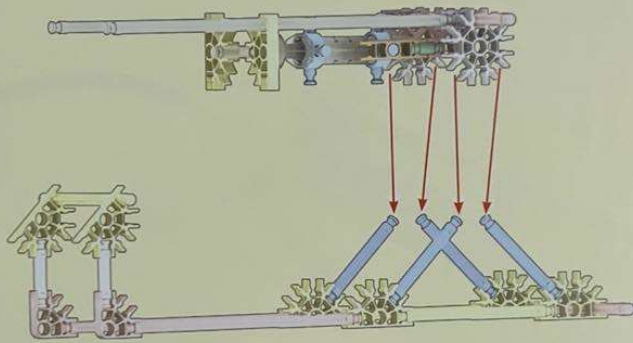
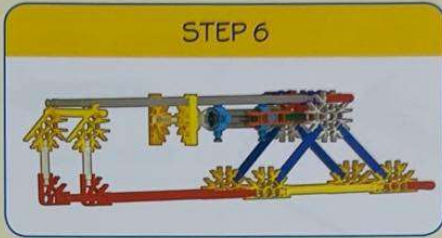
步驟 4-5

準備以下配件，並照著圖解組裝積木配件

現代可移動式的跨橋運作機制與中古世紀的跨橋大致相同。部分橋上的通道可以舉起或是擺動後，讓橋下的船隻可以順利通過。

CONNECT THE PARTS

STEP 6



CASTLE MONTEBELLO

Castle Montebello, pictured to the right, can be found in Switzerland. This castle is over 700 years old!



STEP 1 2 3 4 5 6 7

Moving Creations with **k'nex**

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連結配件

步驟 6

蒙提貝羅城堡

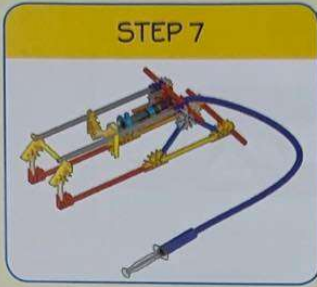
右圖中的蒙提貝羅城堡位於瑞士，已經有超過 700 年的歷史。

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Hand Playmate
God Playmate

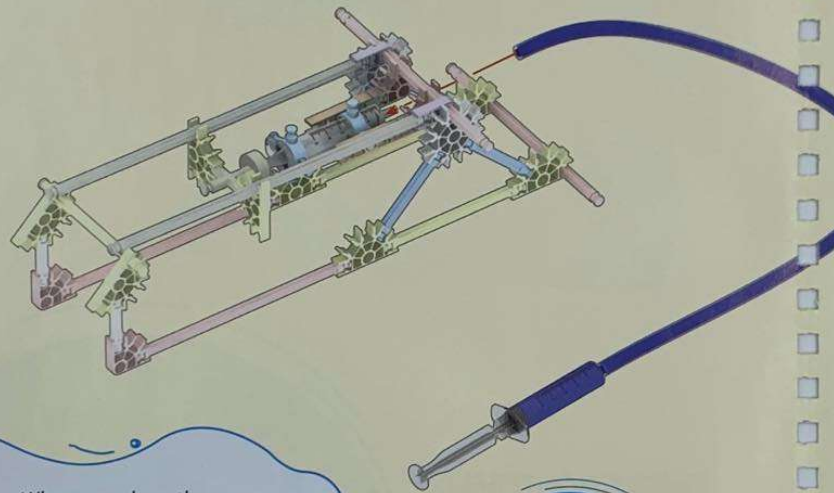
CONNECT THE CHAIN

STEP 7



GATHER THESE PIECES:

- 1  5mL
- 1 Short Tube



When you close the pump, you are shifting the water molecules inside the tube. The pressure created from shifting the water molecules raises and lowers the drawbridge. How cool is that?

See pages 44-46 for a refresher on how to fill up the pump with water.

STEP 1 2 3 4 5 6 7

連結鎖鏈(液體動力裝置)

步驟 7

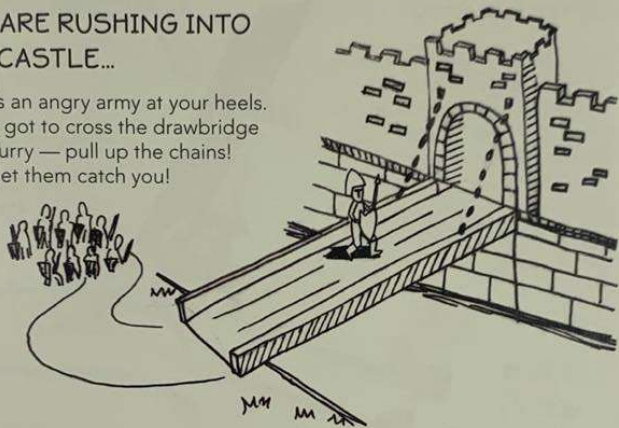
準備以下配件，並照著圖解組裝積木配件

當你關閉幫浦的時候，此時你也在移動管子裡的水分子。在移動水分子的過程中所產生的液體壓力就能夠驅動跨橋升降。是不是很酷呢？

IMAGINE!

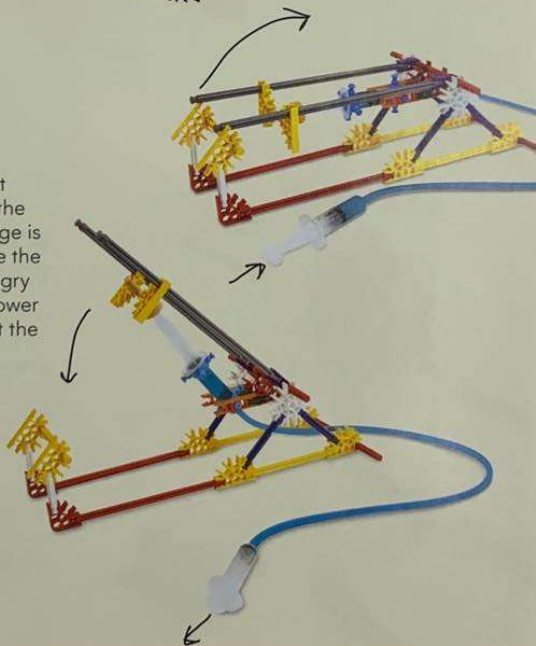
YOU ARE RUSHING INTO THE CASTLE...

There's an angry army at your heels. You've got to cross the drawbridge fast. Hurry — pull up the chains! Don't let them catch you!



LIFT IT!

Push the pump in to start lifting the chains. When the pump is closed, the bridge is at its highest point. Once the coast is clear, and the angry army has disappeared, lower the bridge by pulling out the pump again.



想像一下

你正要衝進城堡裡

有一個軍隊快要追上你了，你必須趕快衝進城堡裡！快~趕緊收起跨橋，別讓敵人抓到你了！

升起來！

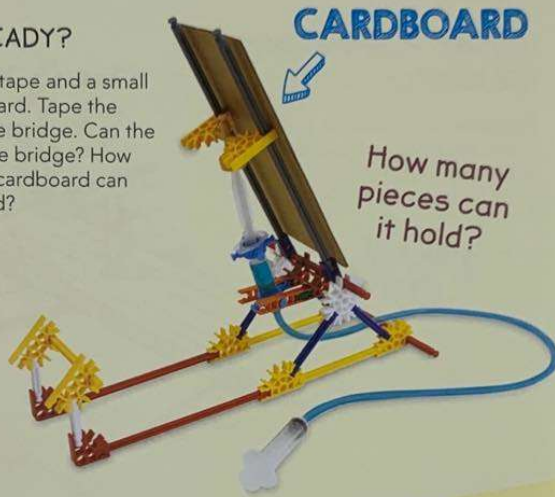
推進幫浦，讓跨橋升起！當完全推進幫浦關閉後，跨橋會升在最高處。當敵人軍隊遠離，河岸淨空後，拉回幫浦再次幫跨橋降下來吧！

THINK BIGGER!

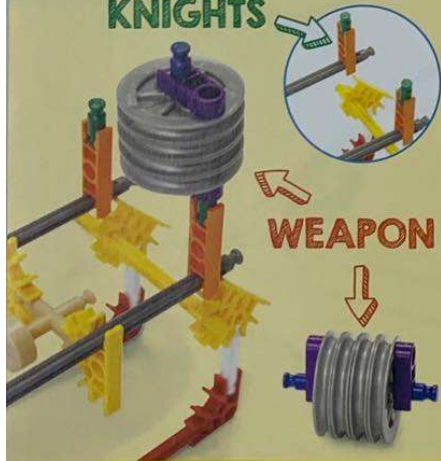
ARE YOU READY?

Grab a piece of tape and a small piece of cardboard. Tape the cardboard to the bridge. Can the chains still lift the bridge? How many pieces of cardboard can your bridge hold?

Will it work?



KNIGHTS



WHAT ELSE COULD YOU TRY?

Use your orange and green K'NEX® pieces to build a pair of knights. Connect them to the end of the platform. Then make a weapon, using four wheels, a blue rod, and two purple connectors. Fit the purple connector on top of the green piece. How do the knights and weapon affect the forces on the drawbridge?

進階思考

準備好了嗎?

準備一段膠帶以及小片的卡板，將小卡片板用膠帶黏在升降橋面上，試試操作幫浦是否能順利升起橋呢？在橋面上加上更多小卡片板，試試看升降橋最多能承載幾片小卡片板呢？

KNIGHTS 護衛騎士

WEAPON 武器

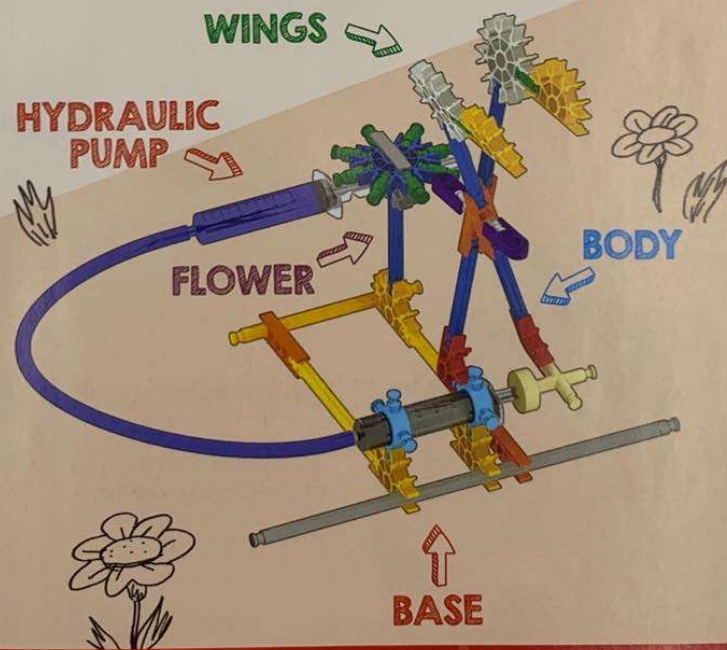
我們還能做那些嘗試呢？

利用橘色與綠色的 K'NEX 配件來建造一對護衛騎士，並將他們與橋面尾部連結。接著用 K'NEX 配件的四個輪子、藍色感與兩根紫色連結器製作出武器。將武器利用綠色配件連結在護衛騎士上。觀察護衛騎士與武器加上橋面後如何影響升降橋的運作？

BUTTERFLY

LET'S JOURNEY TO
THE AMAZON...

Hundreds of butterfly species live in the rainforest. They flit from flower to flower, looking for a sweet drink. In this activity, you'll build a butterfly that moves by hydraulics.



BUTTERFLY 蝴蝶展翅.....P73

讓我們啟程前往亞馬遜雨林吧

好幾百種的蝴蝶們生活在雨林中，在花叢上飛來飛去，找尋花上甜甜的蜜汁。在這個遊戲活動中，你將學到如何利用液體動力來建構一個像是蝴蝶揮動翅膀的機械裝置！

WINGS 翅膀

HYDRAULIC PUMP 液體動力裝置

BODY 身體

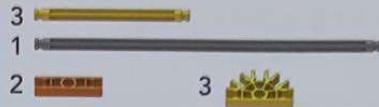
FLOWER 花卉

BASE 基座

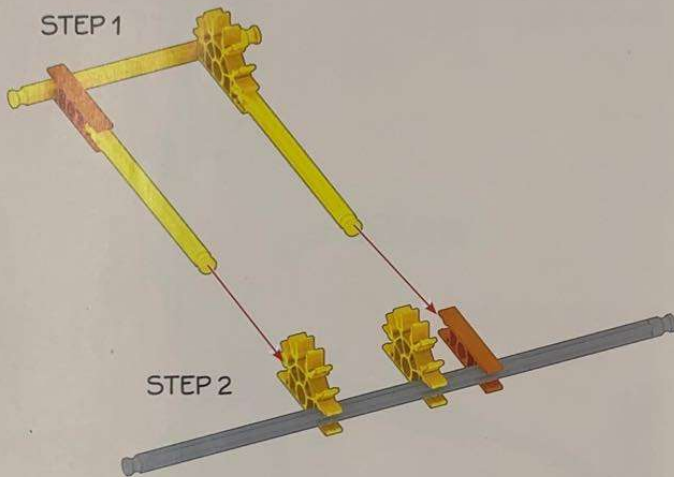
BUILD THE BASE

STEPS 1-2

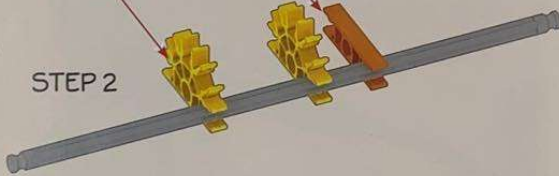
GATHER THESE PIECES:



STEP 1



STEP 2



SWEET PNEUMATICS

A butterfly's long nose acts just like a drinking straw. Air pressure helps to push nectar up into its mouth. That's some sweet pneumatics!

STEP **1** 2 3 4 5 6 7 8

建構基座

步驟 1-2

準備以下配件，並照著圖解組裝積木配件

步驟 1

步驟 2

甜蜜的氣體動力學

蝴蝶的長鼻子就好像我們人類用的吸管一樣，利用氣壓將花蜜吸入嘴中。真是甜蜜的氣體動力學問！

BUILD THE FLOWER

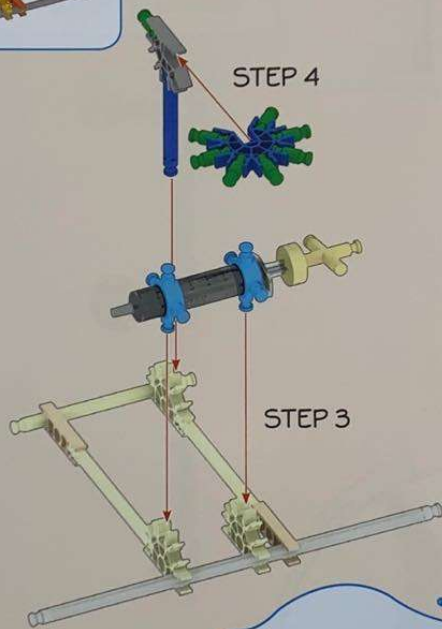
STEPS 3-4



GATHER THESE PIECES:

8 1 1 1

1



Flowers are born from a process called pollination. Butterflies and other animals help move pollen from one flower to another. This new pollen allows a flower to produce a seed. One day, this seed will bloom into a flower!

STEP 1 2 3 4 5 6 7 8

Moving Creations with **k'nex**

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建構花卉

步驟 3-4

準備以下配件，並照著圖解組裝積木配件

步驟 4

步驟 3

花卉的誕生是由一種稱作“授粉作用”的過程而來的。蝴蝶或是其他的生物幫忙將花粉在花卉之間移動傳遞。當花卉接收到新的花粉後就能產出種子，而這顆種子在往後將成長為新的花卉!

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Hand2Mind
God Playmate

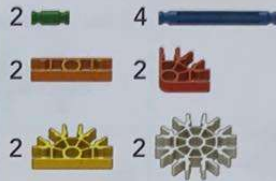
BUILD THE WINGS

STEP 5

x2



GATHER THESE PIECES:



x2



A BUTTERFLY'S COLORS

Butterflies come in all different colors. But why is this? It's because butterflies use their colors to communicate. Sometimes a butterfly uses its color to blend into the surroundings. Other times, a butterfly uses its color to warn other animals not to eat it.



STEP 1 2 3 4 5 6 7 8

建構翅膀

步驟 5

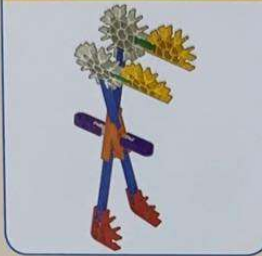
準備以下配件，並照著圖解組裝積木配件

蝴蝶的顏色

蝴蝶有非常多種顏色，為什麼呢？這是因為蝴蝶們會利用身上的顏色來彼此溝通，有些時候蝴蝶也會利用身上的顏色將自己融入環境的顏色，甚至是利用自己身上的色彩來警告其他生物避免自己被獵食！

BUILD THE BODY

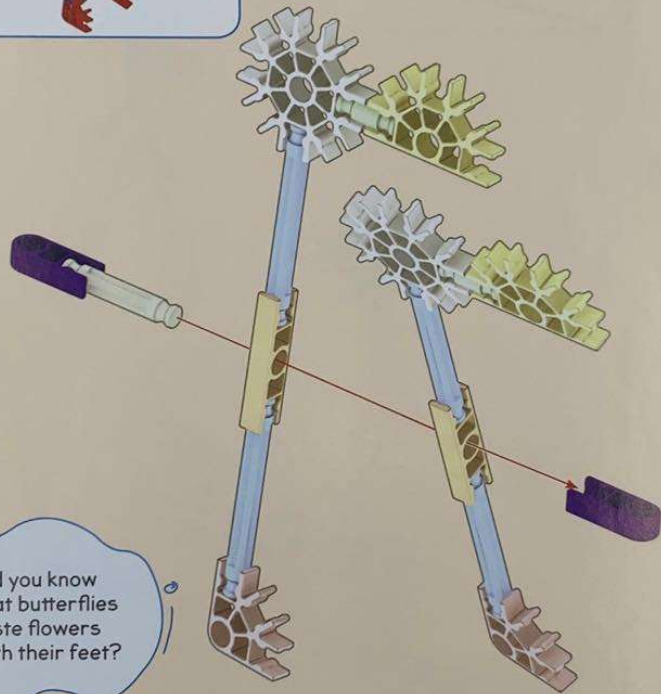
STEP 6



GATHER THESE PIECES:

1

2



Did you know
that butterflies
taste flowers
with their feet?

STEP 1 2 3 4 5 6 7 8

建構身體

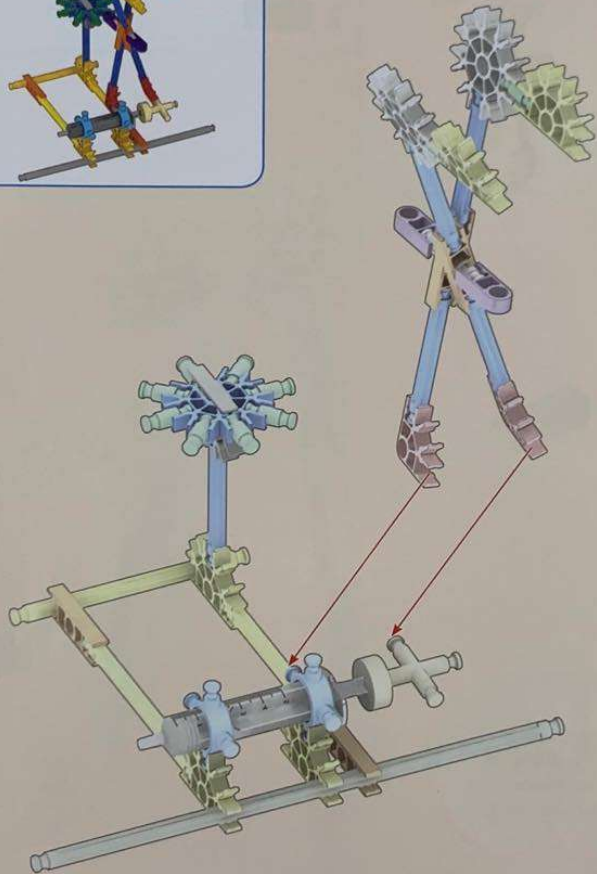
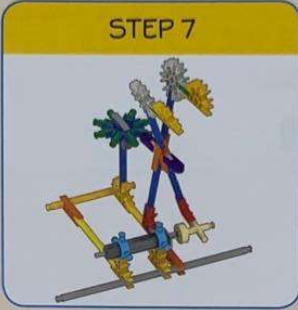
步驟 6

準備以下配件，並照著圖解組裝積木配件

你知道蝴蝶們是利用牠們的腳來品嚐花蜜的甘甜味嗎？

CONNECT THE PARTS

STEP 7



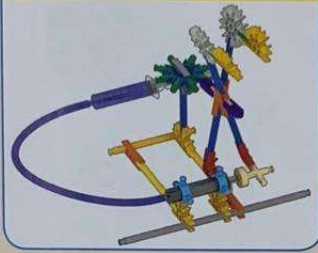
STEP 1 2 3 4 5 6 7 8

連結配件


步驟 7

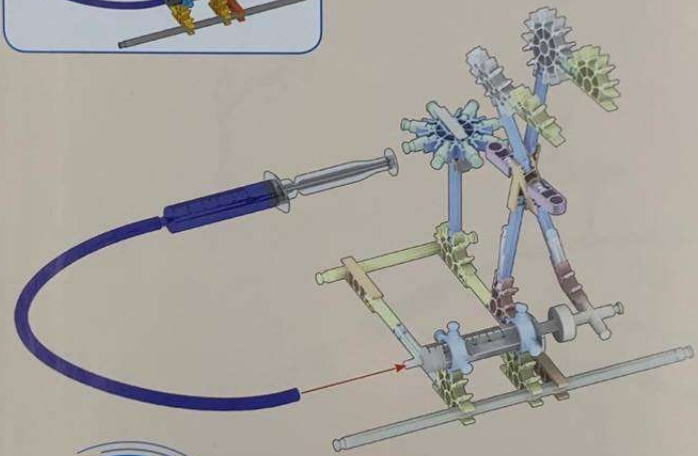
ADD THE HYDRAULICS

STEP 8



GATHER THESE PIECES:

- 1  5mL
- 1 Short Tube



See pages 44-46 for a refresher on how to fill up the pump with water.

Water inside the tube makes the wings move smoothly. With only air in the tube, the wings would jerk around. That's because air molecules would squish together.

STEP 1 2 3 4 5 6 7 8

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連結液體動力裝置

步驟 8

準備以下配件，並照著圖解組裝積木配件

可參閱 P44-46 複習一下如何將幫浦充滿水

在管子中的水能讓翅膀流暢地擺動。如果管子裡裝的是空氣，翅膀則是會變成瞬間的作動。這是因為空氣分子總是擠壓在一起的關係！

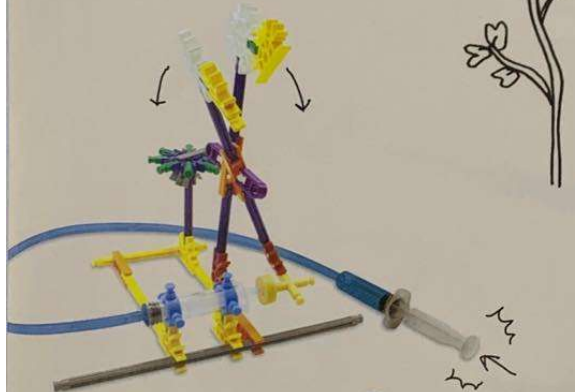
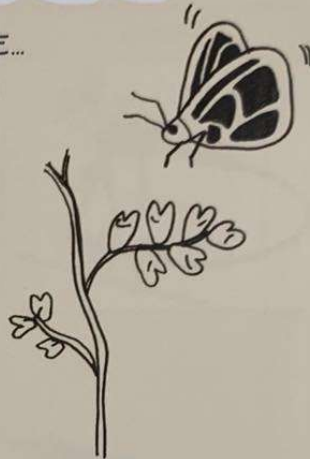
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甘王元·伴
G d Playmate

IMAGINE!

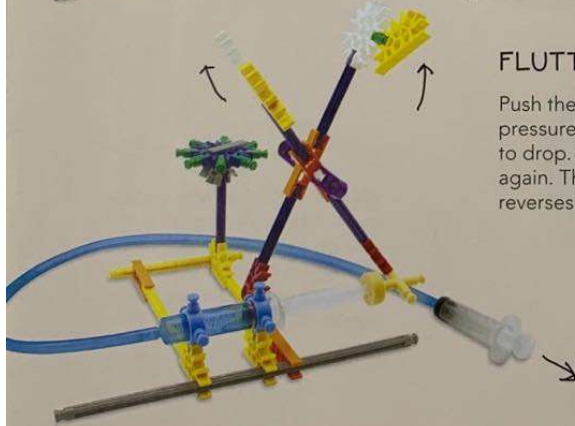
YOU ARE HIDING IN A TREE...

You're a butterfly expert on a special trip. You've just discovered a new species. And you've got to study its habits. Keep still! It's about to land.



FLUTTER!

Push the pump in. The pressure causes the wings to drop. Pull the pump out again. The flow of water reverses. The wings lift!



想像一下

你正躲在一棵樹上

你是一位蝴蝶專家並正進行一趟特別的旅行。你剛發現了一個新的蝴蝶物種並且你需要研究牠們的習性。躲好別動! 蝴蝶正要開始要降落在樹上嘍!

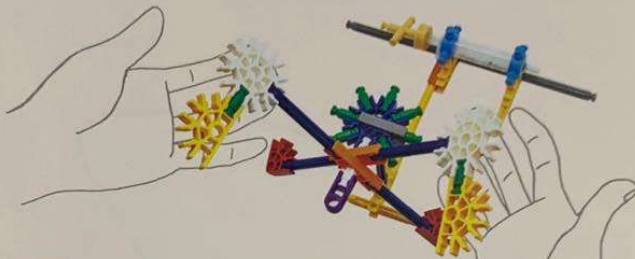
展翅

推進幫浦，幫浦中的壓力會讓翅膀降下。再拉回幫浦，管子中的水又會反方向流回，使得翅膀舉起上升!

THINK BIGGER!

ARE YOU READY?

Detach the butterfly from the pump. Remove one green K'NEX® piece from the flower. Then remove one purple piece that holds the butterfly together in the middle. From the same side, connect the white rod to the open space on the flower. Perch your butterfly on its flower. Try out different wing positions with your hands.



Butterflies hold their wings in different ways. They lay them flat to warm up in the sun. They fold them up to rest. Some butterflies make wing noises to scare off predators.

BUTTERFLY CAMOUFLAGE

Some butterflies have built-in camouflage. This protects them from predators. Their wings have patterns that blend in with leaves, flowers, or trees.



進階思考

你準備好了嗎?

將幫浦與蝴蝶主體分離，並將一個綠色的 K'NEX 配件從花上移除，再將一個紫色配件從蝴蝶中心移除。在剛剛移除配件的地方，使用白色配件桿與花上空出來位置相連結，將蝴蝶暫時放置在花上，並利用雙手試驗不同的蝴蝶展翅角度。（請見下方附圖）

蝴蝶會用不同方式作動牠們的翅膀。例如在曬太陽時牠們會將翅膀展開平放，休息時將翅膀收摺回來，有些蝴蝶則會透過拍動翅膀產生噪音來嚇跑牠們的獵食者。

蝴蝶的偽裝術

有些蝴蝶有著天生的偽裝術，而這些身上的偽裝能夠保護牠們不被獵食者發現。牠們的翅膀上會有特殊的花紋或斑點，使得牠們能夠在視覺上融入生存環境中的物體像是花、葉子或是樹。

THINK BIGGER!

WHAT ELSE COULD YOU TRY?

Grab some paper, scissors, markers or crayons, and tape. Trace the wing outline below onto your paper two times. Then, color the wings to blend in with the rainforest. When you are finished, cut out your wings. Tape the disguise onto the butterfly, and then flap the wings. How does air move around the butterfly now?



進階思考

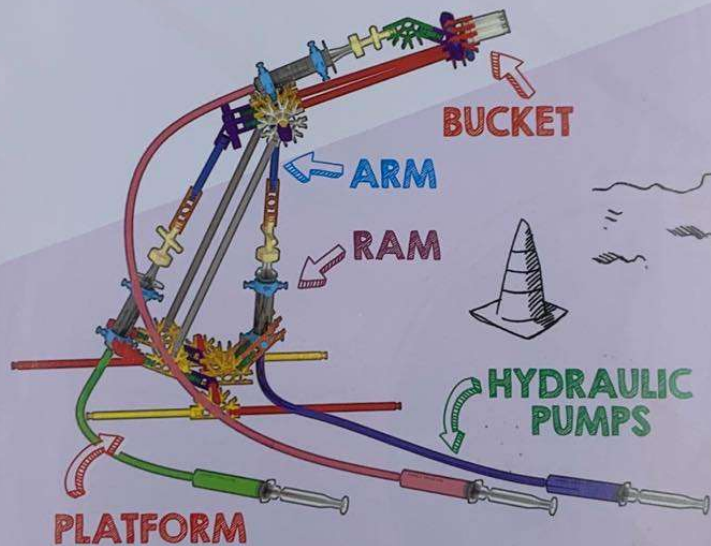
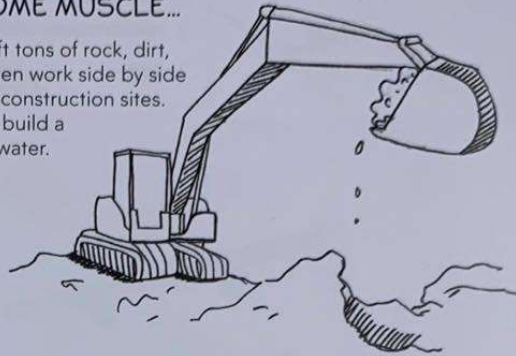
我們還能做些甚麼不一樣的嘗試呢？

準備一些紙、剪刀、彩色筆或是蠟筆、以及膠帶。將下面白色圖的形狀描繪在你的白紙上，描出兩個翅膀，並用你的色筆將翅膀上色，自由創作圖案並試著將翅膀的圖案融入雨林中的植物。繪製完成後將兩個翅膀用剪刀剪下來，拿著這兩個畫好的翅膀揮動幾下，感覺一下揮動翅膀時周遭的空氣是如何流動的呢？

DIGGER

LET'S FLEX SOME MUSCLE...

Diggers can easily lift tons of rock, dirt, and metals. They often work side by side with dump trucks at construction sites. In this activity, you'll build a digger powered by water.



DIGGER 挖土機.....P83

讓我們展現一下力量吧

挖土機可以輕鬆地舉起幾噸重的石頭、砂土以及金屬物。砂石車在工地時通常都會和卡車或砂石車待在一起工作。在這個遊戲活動中，你將學到如何利用液體動力來建構一台挖土機！

BUCKET 鏟斗

ARM 液壓斗桿

RAM 液壓缸

HYDRAULIC PUMPS 液體壓力裝置

PLATFORM 平台

BUILD THE PLATFORM

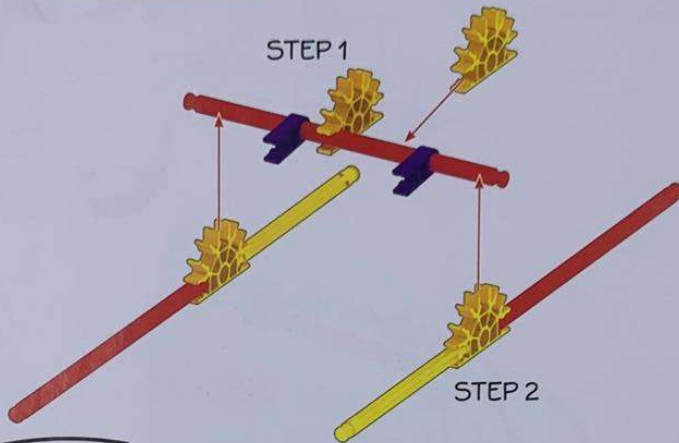
STEPS 1-2



GATHER THESE PIECES:



STEP 1



STEP 2



YELLOW

Have you ever noticed that diggers tend to be yellow? This is because yellow is the color of safety. Diggers are dangerous machines and must be used with caution.

STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構平台

步驟 1-2

準備以下配件，並照著圖解組裝積木配件

步驟 1

步驟 2

黃色

你有發現挖土機幾乎都是黃色的嗎？這是因為黃色是安全的代表色！挖土機本身是危險的機械裝置所以必須特別注意運作上的安全！

BUILD THE RAM

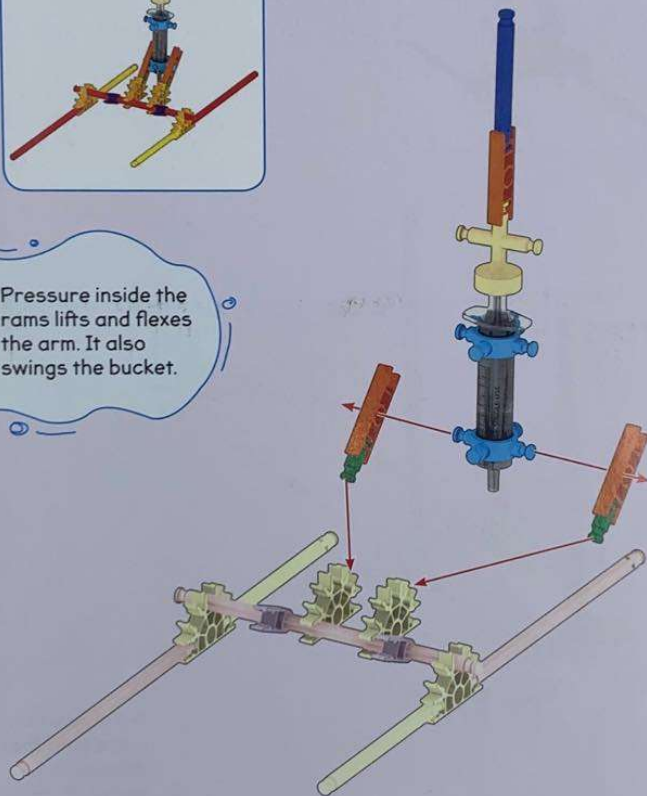
STEP 3



GATHER THESE PIECES:



Pressure inside the rams lifts and flexes the arm. It also swings the bucket.



STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構液壓缸

步驟 3

準備以下配件，並照著圖解組裝積木配件

在液壓缸裡的壓力可以讓動臂舉起以及伸展，同時也能控制鏟斗的擺動！

BUILD THE ARM

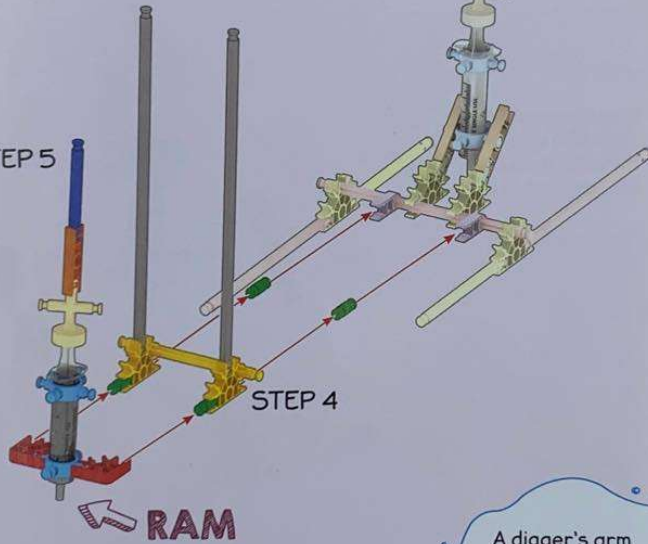
STEPS 4-5



GATHER THESE PIECES:



STEP 5



STEP 4

A digger's arm is the part that does all the heavy lifting.

STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構斗桿

步驟 4-5

準備以下配件，並照著圖解組裝積木配件

步驟 5

步驟 4

斗桿是挖土機內用來抬舉重物的裝置!

BUILD THE BOOM

STEP 6

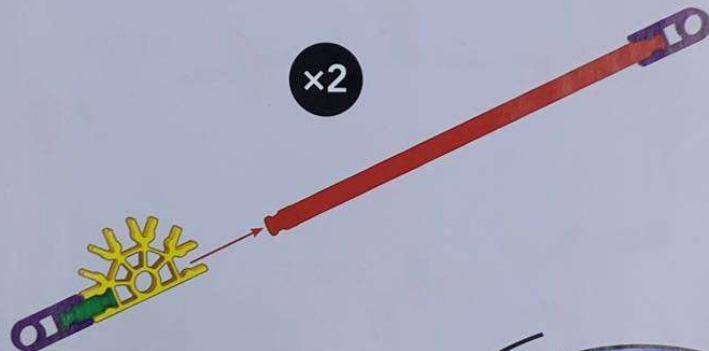
x2



GATHER THESE PIECES:



x2



EXCAVATOR VS. DIGGER

Diggers are sometimes referred to as excavators. Excavators are used for lots of projects, including construction, mining, and forestry work.



STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構動臂

步驟 6

準備以下配件，並照著圖解組裝積木配件

挖掘機 VS. 挖土機

挖土機也常被稱為挖掘機，它們都是被運用在工程現場像是礦場或是林場。

BUILD THE BOOM

STEPS 7-8

GATHER THESE PIECES:



BUCKET

STEP 8

STEP 7

THE PURPOSE OF TEETH

The "teeth" of the digger's bucket break up solid dirt and rocks.

STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構動臂

步驟 7-8

準備以下配件，並照著圖解組裝積木配件

步驟 8

鏟斗

步驟 7

鏟斗前端鋸齒的用途

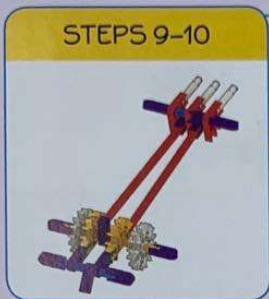
鏟斗前端鋸齒是用來挖破堅硬的土層及岩石層。

ADD HINGES

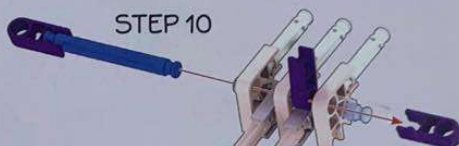
STEPS 9-10

GATHER THESE PIECES:

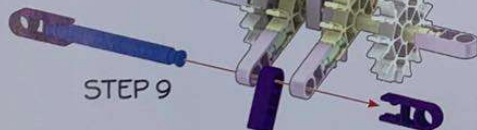
2  6 



STEP 10



STEP 9



A hydraulic digger can lift up to 9000 tons of earth in just one hour!

STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

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連結連軸

步驟 9-10

準備以下配件，並照著圖解組裝積木配件

步驟 10

步驟 9

一台液壓的挖土機在一小時內可以舉起約 9000 噸重的沙土。

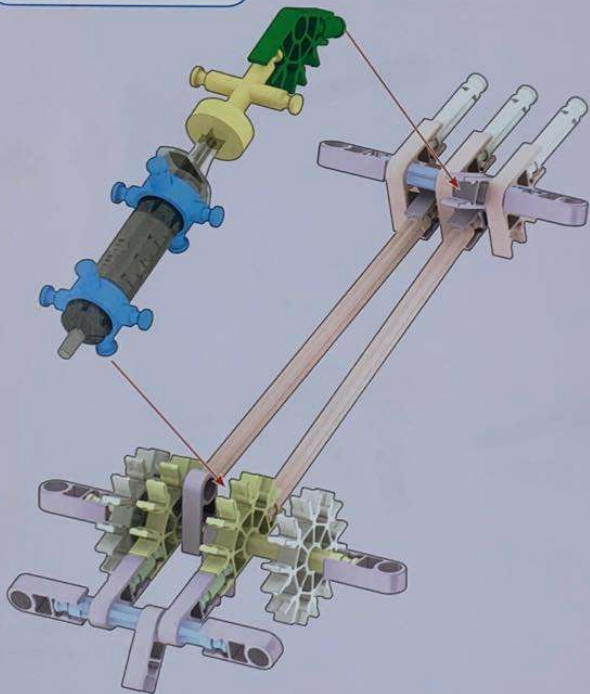
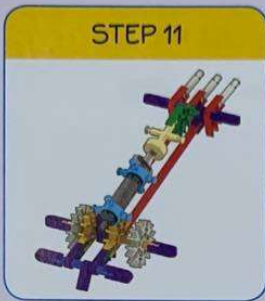
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好玩伴
Good Playmate

BUILD THE RAM

STEP 11

GATHER THESE PIECES:



STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

建構液壓缸

步驟 11

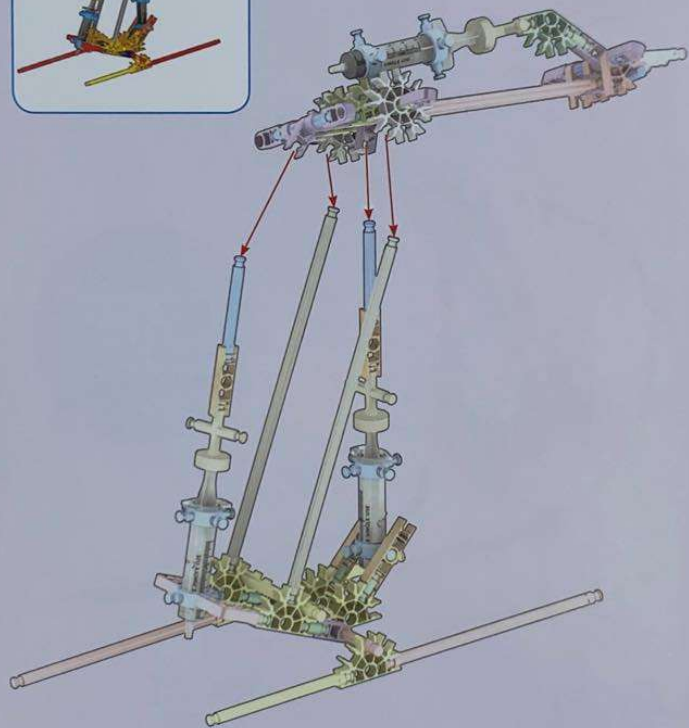
準備以下配件，並照著圖解組裝積木配件

CONNECT THE PARTS

STEP 12



Did you know that hydraulic excavators have been around since the 1800s?



STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

Moving Creations with **k'nex**

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連結配件

步驟 12

你知道在西元 1800 年左右就有液壓挖土機的裝置出現了嗎？


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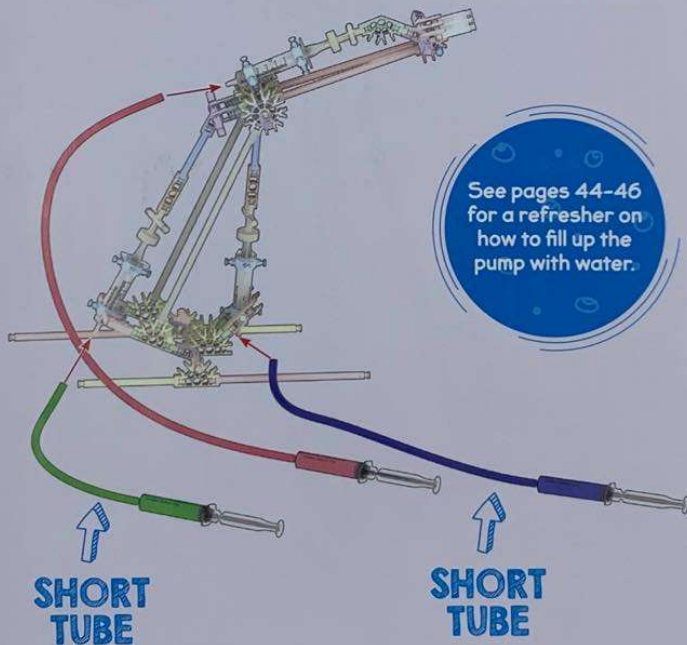
好玩伴
Good Playmate

CONNECT THE PUMPS

STEP 13

GATHER THESE PIECES:

3  5mL
2 Short Tubes, 1 Long Tube



See pages 44-46
for a refresher on
how to fill up the
pump with water.

STEP 1 2 3 4 5 6 7 8 9 10 11 12 13

連結幫浦

步驟 12

準備以下配件，並照著圖解組裝積木配件

可參閱 P44-46 複習一下如何將幫浦充滿水

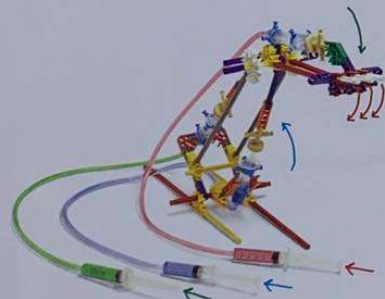
短管

短管

IMAGINE!

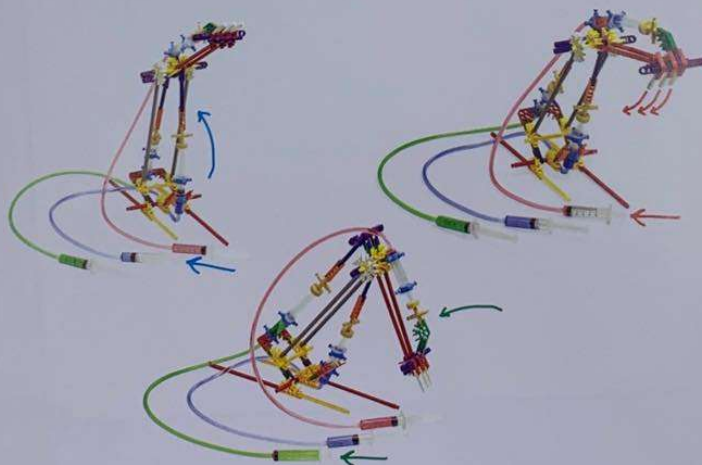
YOU ARE DEEP INSIDE THE GROUND...

A new skyscraper will rise above your city. It's your job to dig out its spot. From your seat in the air, you'll be moving tons of earth and rock. Get digging!



DIG IT!

Push and pull each pump's piston to move different parts of the digger. You can lift the arm, extend the ram, and swing the bucket. Use tape to secure the base to a flat surface if needed.



想像一下

你正在很深的地底下

你所在的城市正在建造一棟摩天大樓，你的任務是要在建造地點挖掘出地基施工的地方，坐在挖土機上方駕駛座的你需要挖出大量的土石！開始動手挖掘吧！

開挖嘍！

試著推拉幫浦柄來移動挖土機上的不同裝置部位。你可以將挖土機前臂舉起來，伸展斗桿，然後開始擺動挖土機的鏟斗

THINK BIGGER!

ARE YOU READY?

A force is either a push or pull on an object. Your digger's bucket is designed to push on an object. How could you rebuild the bucket so it pulls on an object?

How would you design a new bucket that pulls instead of pushes?

Make a guess – will it work?

Draw your bucket design.

進階思考

你準備好了嗎？

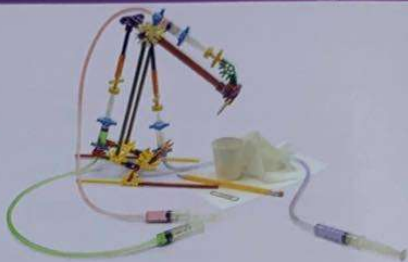
不管是推或是拉一個物體都是一個外力的表現。你的挖土機鏟斗是設計用來推動物品的，動動腦，你是否可以將挖土機的鏟斗重新建造成拉動物品的設計呢？

你會如何將挖土機鏟斗設計成拉動物品的呢？猜猜看！這個設計是否會成功？

將你的設計畫在下方空白處。

CAN YOU TRY IT?

What can your digger pick up? Gather a paper cup, a pencil, a pad of sticky notes, extra K'NEX® pieces, and a tissue. Make a guess about which object the digger can lift off the ground. Test it out and see if you're right!



Object	Result

Some diggers use giant magnets to help them lift heavy steel.

來試試看吧!

你的挖土機能夠舉起那些東西呢? 準備一個紙杯、一枝筆、一本便利貼、沒有用到的 K'NEX 配件、還有一張紙巾。猜猜看你的挖土機能夠將哪些物品舉起來? 測試看看並將結果紀錄在下方的表格!

物品	結果