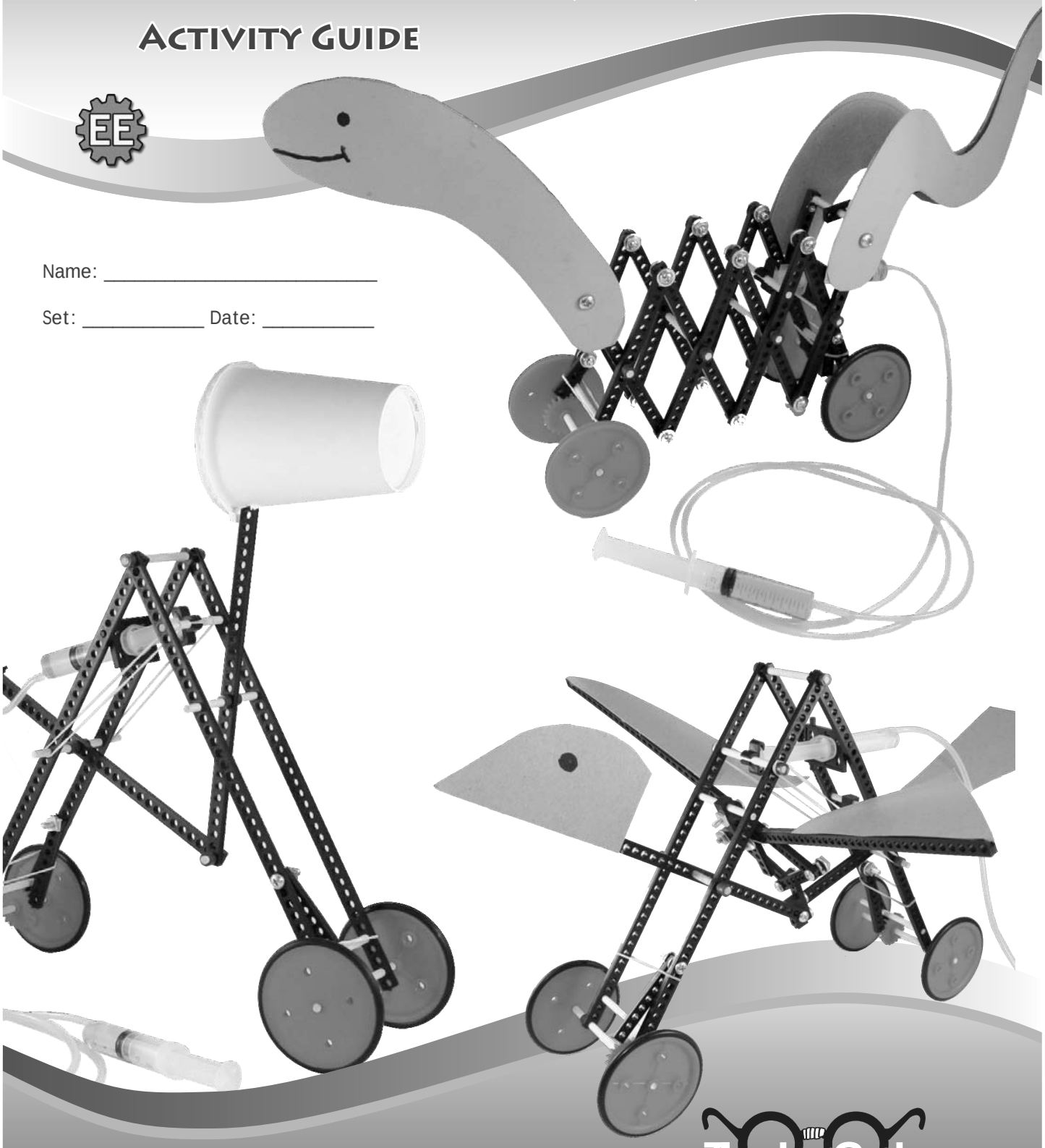
Remote Controlled Hydraulic Pet (Racer)

Activity Guide

Name: _____

Set: _____ Date: _____



TeacherGeek.com

Warning: CHOKING HAZARD
Small Parts. Not for Children Under 3 yrs.

COMPONENTS

These are the minimal parts needed to create one hydraulic pet:

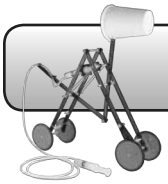
Part:	Quantity:	Picture:
70mm Pulley	4	
Long Link Strip	8	
50 Tooth Gear	1	
20 Tooth Gear	3	
Perpendicular Adaptor	2	
70mm Tire	4	
Dowel	3	
Slide Stop Material	2in	
Galvanized Wire	2ft	
Vinyl Tubing 1/8 I.D.	5ft	
1” Machine Screw #10	5	

Part:	Quantity:	Picture:
Square Nuts #10	10	
10cc Syringe	2	
10cc Syringe Mounts	1	
10cc Syringe Clips	1	

Additional Items Needed

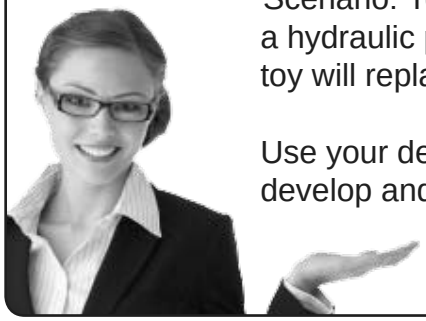
Part:	Quantity:	Picture:
Rubber Bands	4	
Reamer Set (available at teachergeek.com)	1	
Easy Cutter (available at teachergeek.com)	1	
Safety Glasses	1/Student	
Other Found Items	???	

Additional inexpensive parts can be ordered from TeacherGeek to allow more innovation and alternative designs.



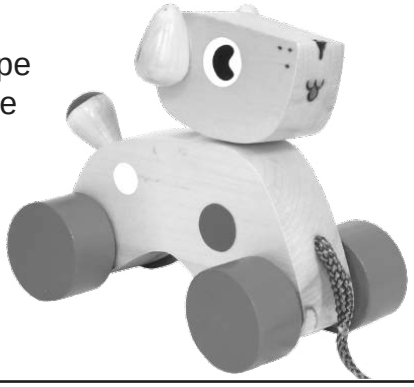
Hydraulic Pet Guide (hydro-racer)

The Challenge



Scenario: You have been hired to design and prototype a hydraulic powered toy for a major manufacturer. The toy will replace the once popular Pull-a-Dog.

Use your design and engineering expertise to develop and prototype a hydraulic pet.



The Criteria

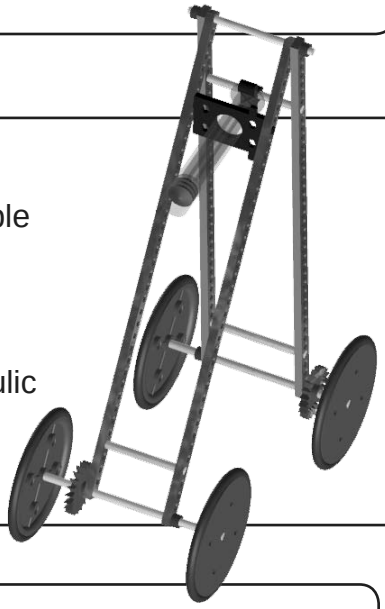
Your toy should meet the following design constraints. It should:

- resemble an animal (insect, bird, fish, dog, etc.) or make-believe creature.
- have parts that move in interesting ways when the toy moves (wings that flap, a head that bobs, a mouth that opens and closes, a tail that wags, etc.).
- be hydraulically powered.
- move forwards and move its parts using hydraulic power (it can't be pulled or pushed).
- be as unique and different as possible.
- have a "catchy" name.
- be attractive and well constructed.

An Example Pet

It is now time to build an example hydraulic pet. Building the example pet will provide you with the knowledge and experience needed to design and construct your own unique hydraulic pet.

Question: What will happen to the example pet when I am done?
Answer: The example pet will be used to create your unique hydraulic pet. You may choose to disassemble the example pet, or modify and add to it.



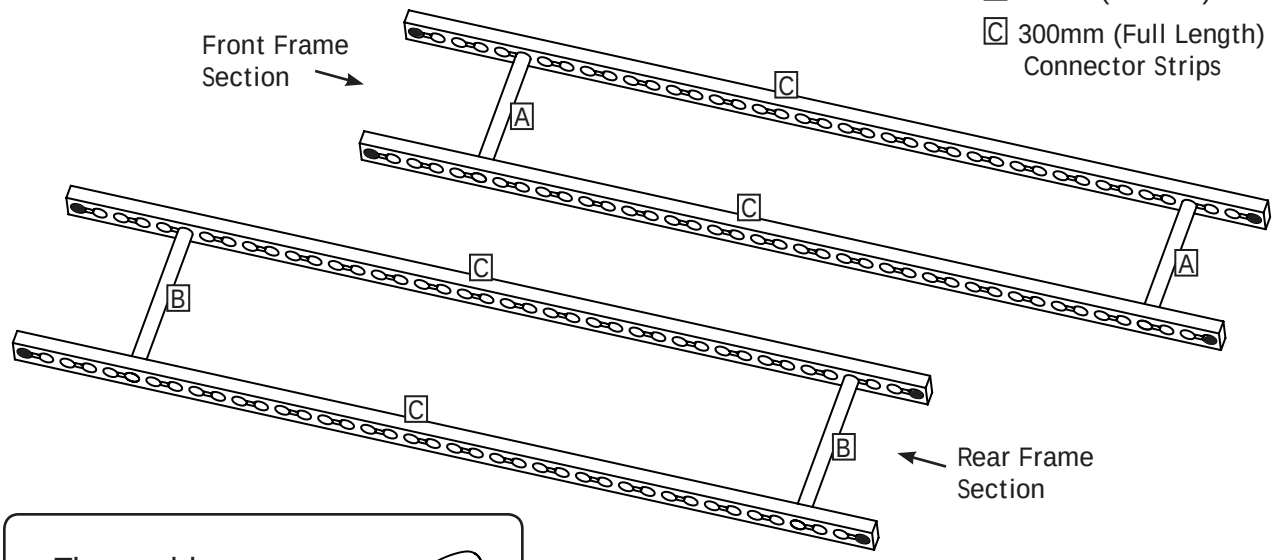
Warning: The small parts in this kit are a CHOKING HAZARD for small children. The parts for this activity and final hydraulic pet are not for children under 3 yrs.

BUILD THE FRAME

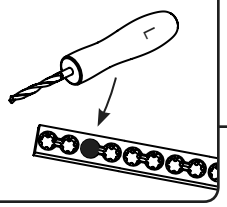
1. Build The Sections

Assemble the front and rear frame sections:

A 55mm (~2 3/16") Dowels
B 65mm (~3 1/8") Dowels
C 300mm (Full Length) Connector Strips

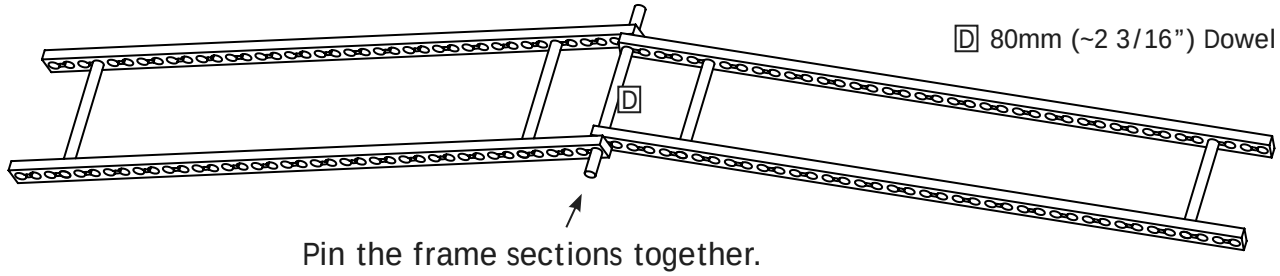


Thoroughly ream the darkened holes with the "L" reamer.



2. Pin The Sections

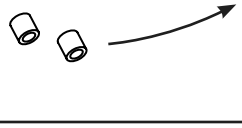
D 80mm (~2 3/16") Dowel

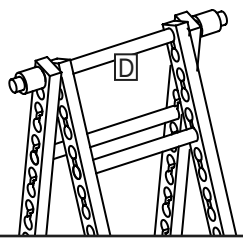


Pin the frame sections together.

3. Slide Stop

Secure dowel D with slide-stop sections.

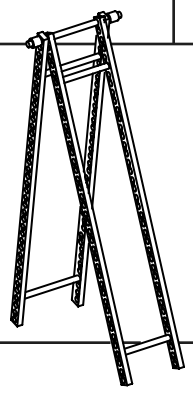




Complete

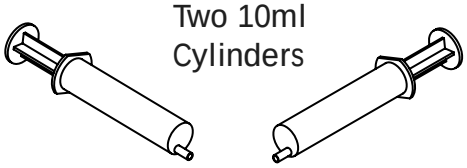
Your example frame is complete.

It's time to build the hydraulic system.



Create The Hydraulics

What Will You Need?



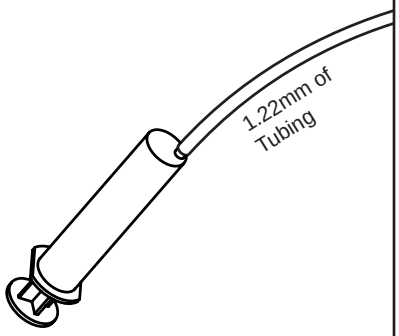
Two 10ml Cylinders

1.22m (4ft) of Tubing

Water

1. Attach Tubing

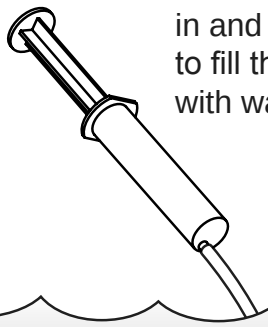
Attach the 1.22m section of tubing to one cylinder.



2. Pull Water In

Place the loose end of the tubing in water.

Push the piston in and pull it back to fill the cylinder with water.



3. Push Air Out

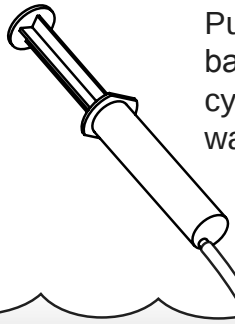
Hold the piston end of the cylinder down (as shown).

Push the air out of the cylinder and tubing, along with some of the water.

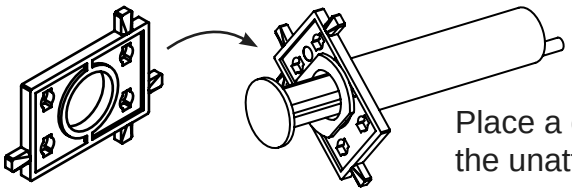
4. Pull Water In (Again)

Place the loose end of the tubing back into water.

Pull the piston back to fill the cylinder with water.



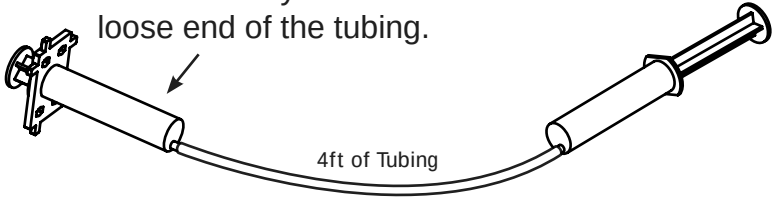
5. Prepare the Second Cylinder



Place a cylinder mount on the unattached cylinder.

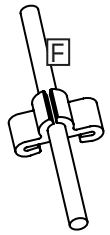
6. Attach the Second Cylinder

Push the piston completely in on the unattached cylinder. Connect it to the loose end of the tubing.



Attach The Hydraulics

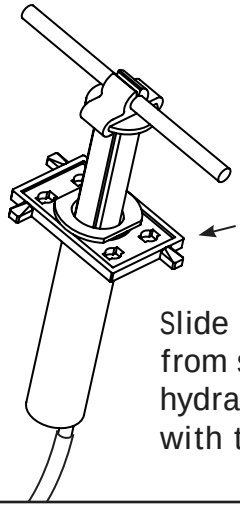
1. Cylinder Clip



F 80mm (~2 3/16") Dowels

Slide the cylinder clip onto the center of the dowel.

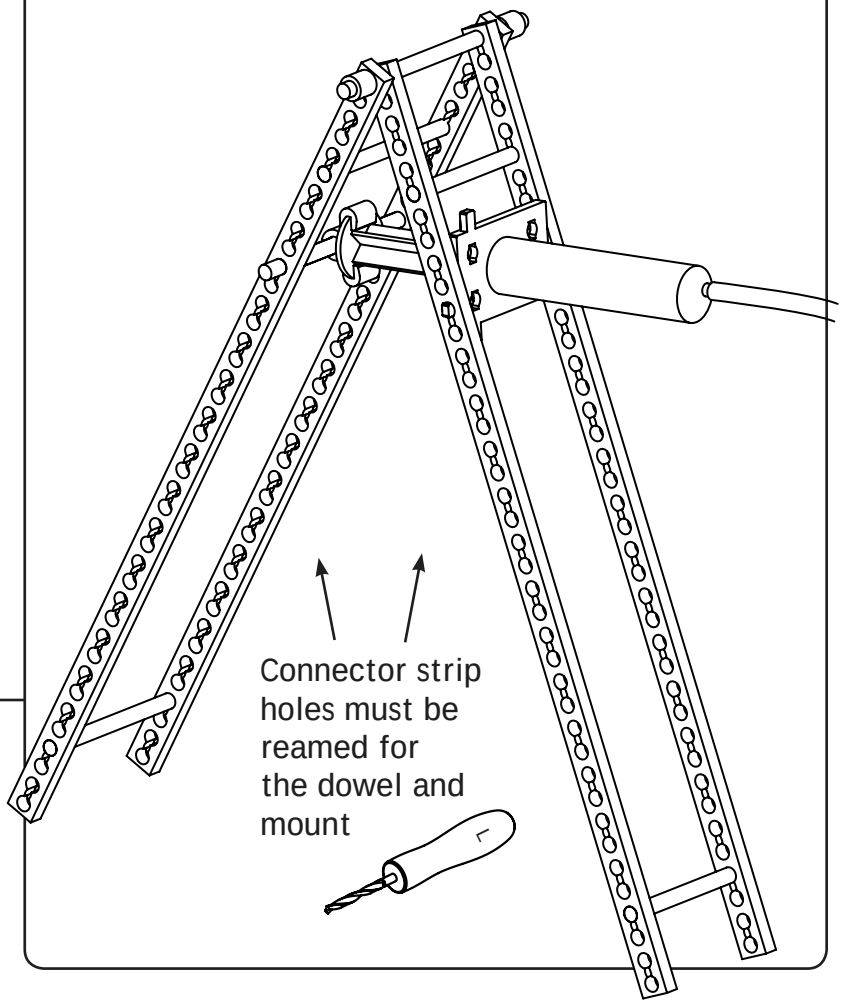
2. Clip On Cylinder



Slide the cylinder clip from step 1 onto the hydraulic cylinder with the mount.

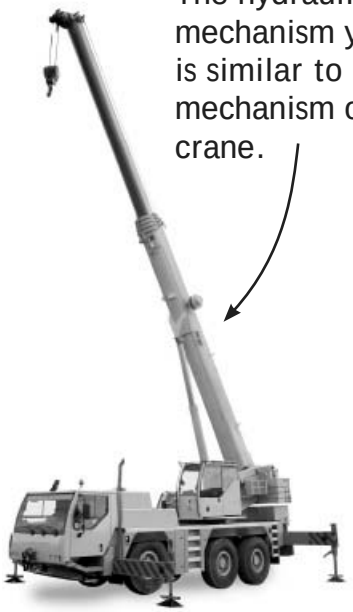
3. Attach The Cylinder

Attach the cylinder to the frame.



Connector strip holes must be reamed for the dowel and mount

The hydraulic lever mechanism you made is similar to the boom mechanism on this crane.

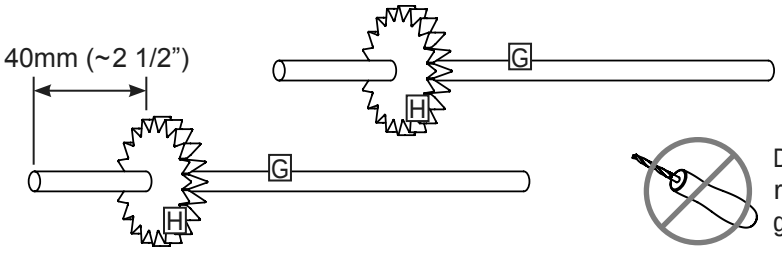


Build The Axles

Build two axles.

G 150mm (~6") Dowels

H 20 Tooth Gears

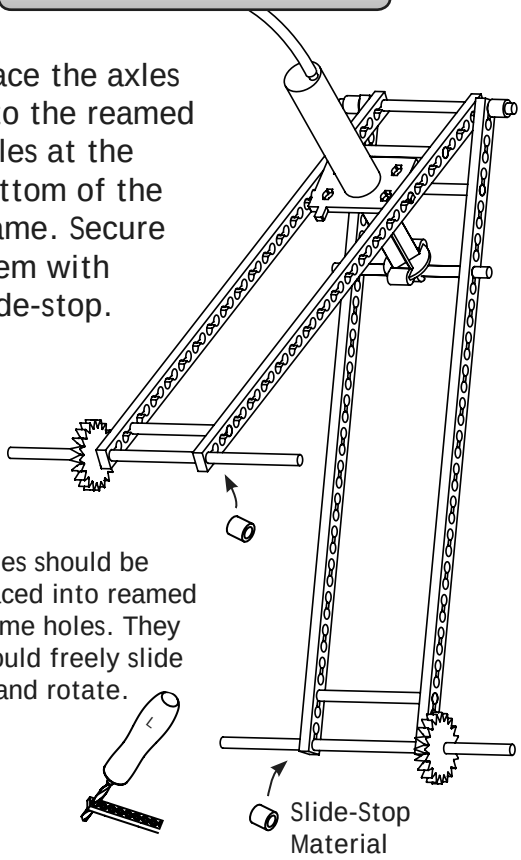


Do not ream the gear holes.

LET IT ROLL

1. Insert Axles

Place the axles into the reamed holes at the bottom of the frame. Secure them with slide-stop.



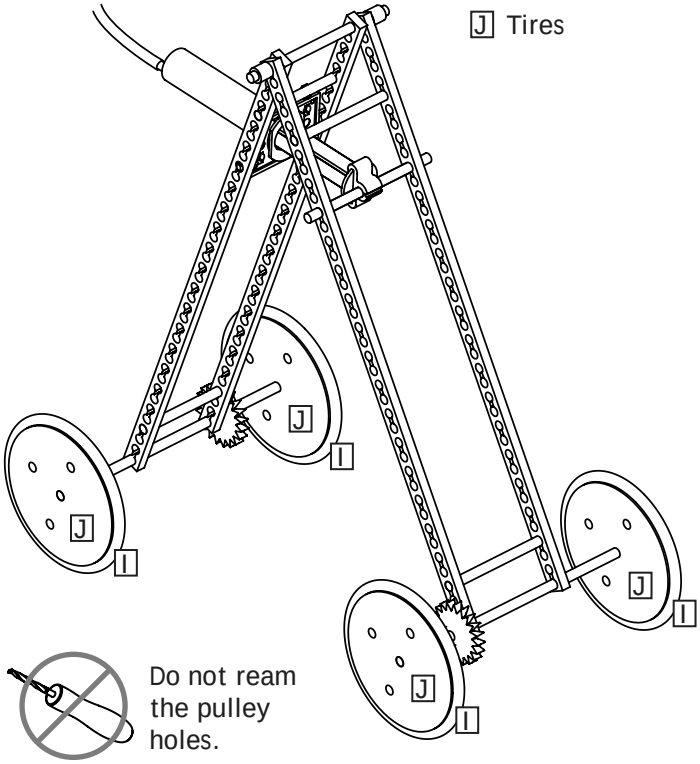
Axles should be placed into reamed frame holes. They should freely slide in and rotate.

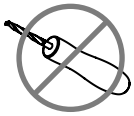
Slide-Stop Material

2. Attach Wheels

Put the wheels on.

I 70mm Pulleys
J Tires





Do not ream the pulley holes.

MOVE IT FORWARD

The Good News: It's time to make your pet move forwards when powered by the remote hydraulic cylinder (remote).

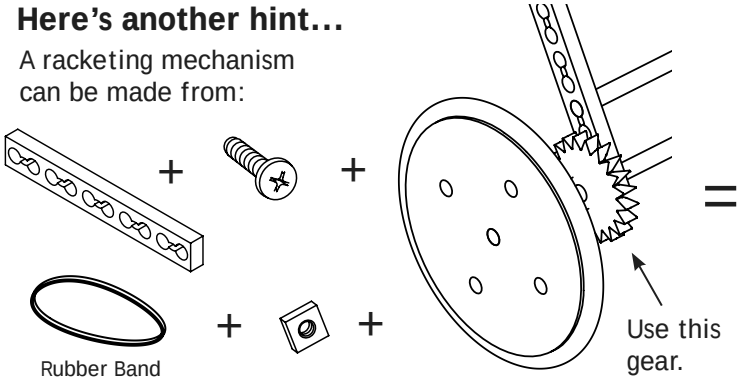
The Bad News: This guide does not tell you how to do it.

Here's a hint...

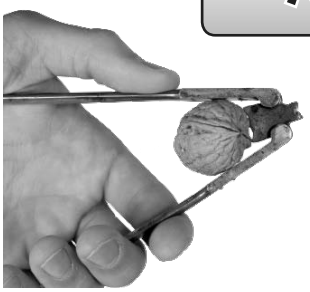
This wrench has the same racketing mechanism you will need on your pet axles.

Here's another hint...

A racketing mechanism can be made from:



MECHANICAL ADVANTAGE



Mechanical Advantage is the relationship between the work going into a system, and work coming out of a system.

A nutcracker allows you to apply a force larger than you could with your bare hand.

Force can be traded for distance, or distance can be traded for force.

WORK IN

A smaller force is applied over a larger distance:

$Force_{in} \bullet Distance_{in}$

10lbs • 1in

=

10in-lbs

=

WORK OUT

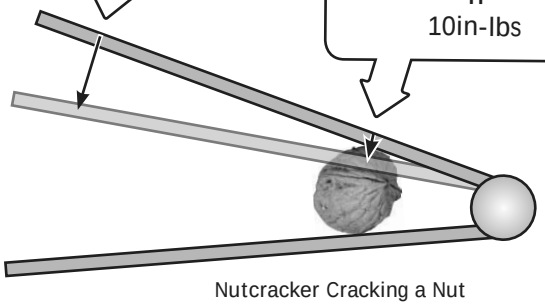
A larger force is applied over a smaller distance:

$Force_{out} \bullet Distance_{out}$

40lbs • .25in

=

10in-lbs



Nutcracker Cracking a Nut

IMA vs. AMA

Some energy will be lost by a machine (mostly through friction).

Ideal Mechanical Advange (IMA) does not account for any energy lost. $\mathbf{Work_{in}} = \mathbf{Work_{out}}$ with IMA.

Actual Mechanical Advantage (AMA) accounts for energy lost. $\mathbf{Work_{out}} < \mathbf{Work_{in}}$ with AMA.

IDEAL MECHANICAL ADVANTAGE

The work input into the machine must equal the work coming out of the machine.

$$\mathbf{Work_{in}} = \mathbf{Work_{out}}$$

$$\mathbf{Force_{in}} \bullet \mathbf{Distance_{in}} = \mathbf{Force_{out}} \bullet \mathbf{Distance_{out}}$$

can be rearranged as

$$\text{Ideal Mechanical Advantage} = \frac{\mathbf{Distance_{in}}}{\mathbf{Distance_{out}}} = \frac{\mathbf{Force_{out}}}{\mathbf{Force_{in}}}$$

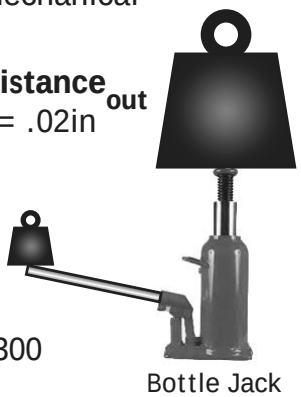
Divide the $Distance_{in}$ by the $Distance_{out}$ or the $Force_{out}$ by the $Force_{in}$ to find the mechanical advantage.

Calculating mechanical advantage:

$Distance_{out}$ = .02in

$Distance_{in}$ = 6in

$$\frac{6in}{.02in} = 300$$



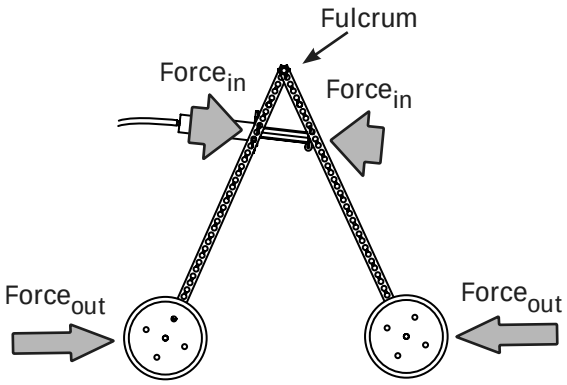
Bottle Jack

The ideal mechanical advantage of the jack can be represented as:

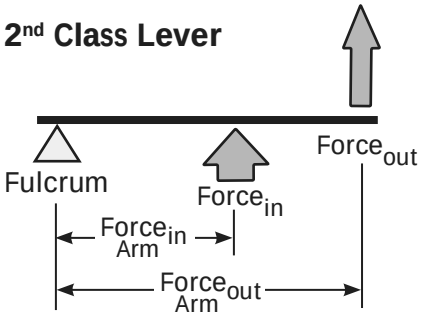
"300" or "300:1" or "300 to 1"

LEVERAGE

The hydraulic pet frame is a second class lever. It trades input force for output distance and speed.



2nd Class Lever

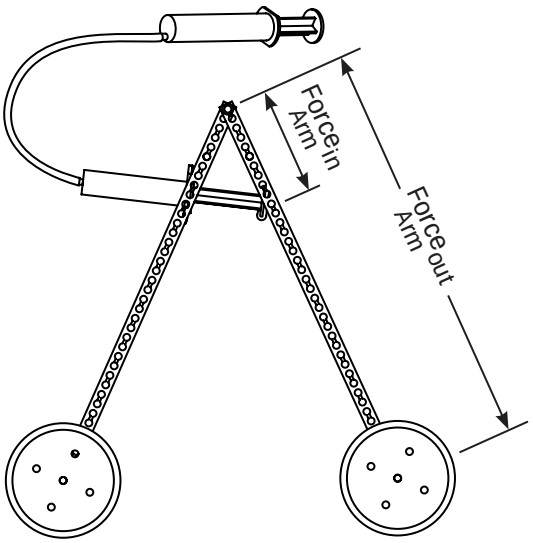


The Force$_{in}$ is often referred to as the "Effort."

The Force$_{in}$ is often referred to as the "Load" or "Resistance."

LEVERAGE = MECHANICAL ADVANTAGE

$$\text{Ideal Mechanical Advantage} = \frac{\text{Force}_{in}\text{ Arm Length}}{\text{Force}_{out}\text{ Arm Length}} = \frac{\text{Distance}_{in}}{\text{Distance}_{out}} = \frac{\text{Force}_{out}}{\text{Force}_{in}}$$



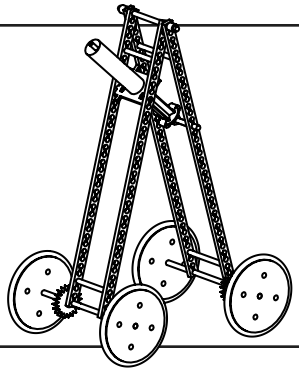
Moving the cylinder down on the frame:
- will decrease the distance the frame expands.
- increase the force of the frame.

Moving the cylinder up on the frame:
- will increase the distance the frame expands.
- decrease the force of the frame.

EXPERIMENT

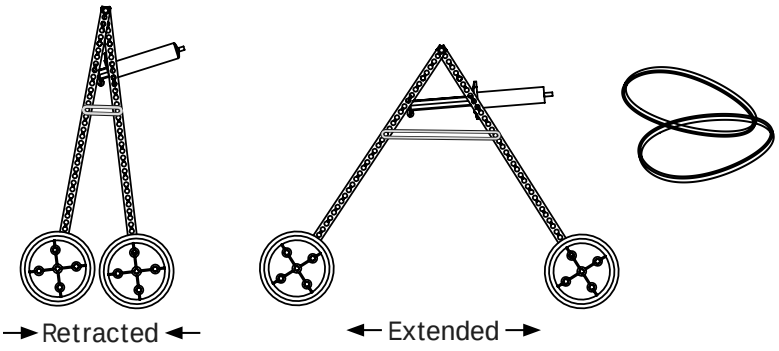
Experiment with different cylinder positions on your pet frame. Find the position that provides you with the ideal mechanical advantage (the perfect balance of force and distance).

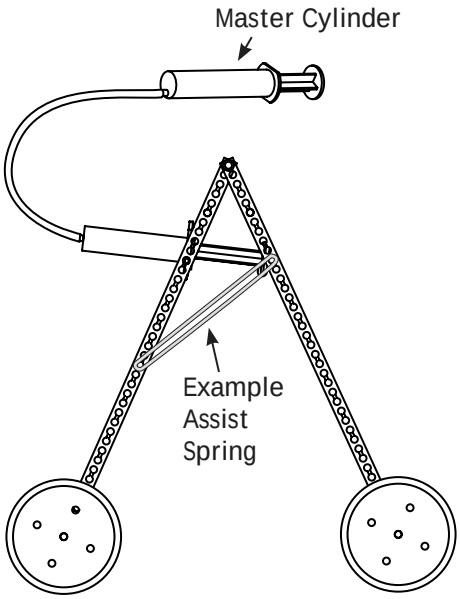
The angle of the cylinder can also change the mechanical advantage.



Assist Springs

Move your pet by pushing and pulling the master cylinder. You'll notice that it's easier to make the pet extend than it is to make it retract. This is mostly due to gravity.





Tip: Use an assist spring on each side of the frame.

You can balance forces needed make the pet extend and retract using assist springs (rubber bands).

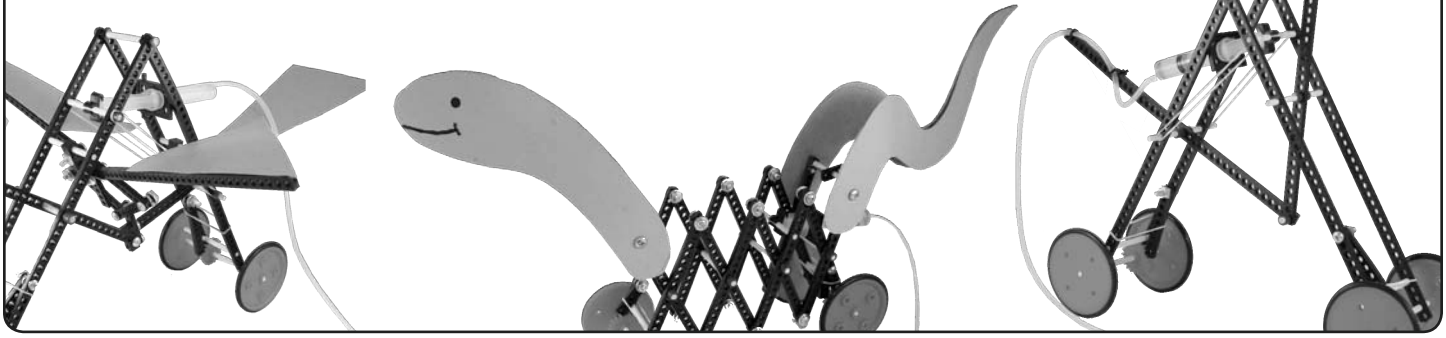
Assist springs gather potential energy as the pet extends. The potential energy is then turned into kinetic energy that helps the pet retract.

Car trunks and garage doors use assist springs to make them easier to open.

Start Thinking...

You should be thinking about what you want your pet to look like and how you want it to move.

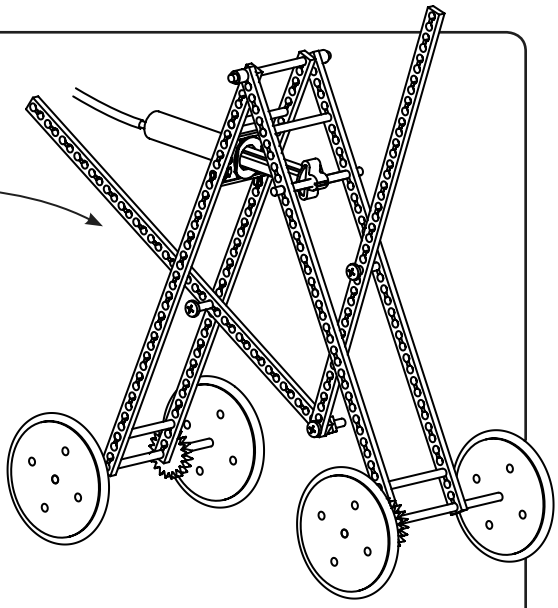
The following pages will show you a few of the many mechanisms that can be used to move features (tails, heads, wings, etc.) on your pet.



LINKAGES

A linkage is a mechanism formed by connected levers.

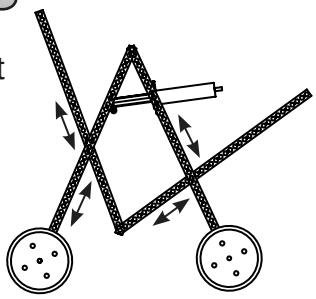
Create the linkage similar to the one shown.
You'll need three bolts and two link strips.



1. Experiment

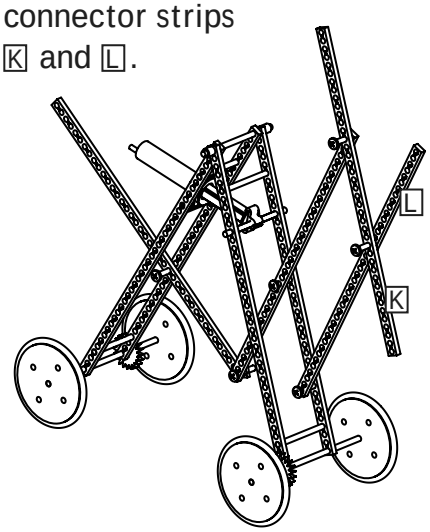
Change the length and pivot points of the linkage.

Notice how the movement of the linkage changes.



2. Expand

Expand the linkage with connector strips K and L.



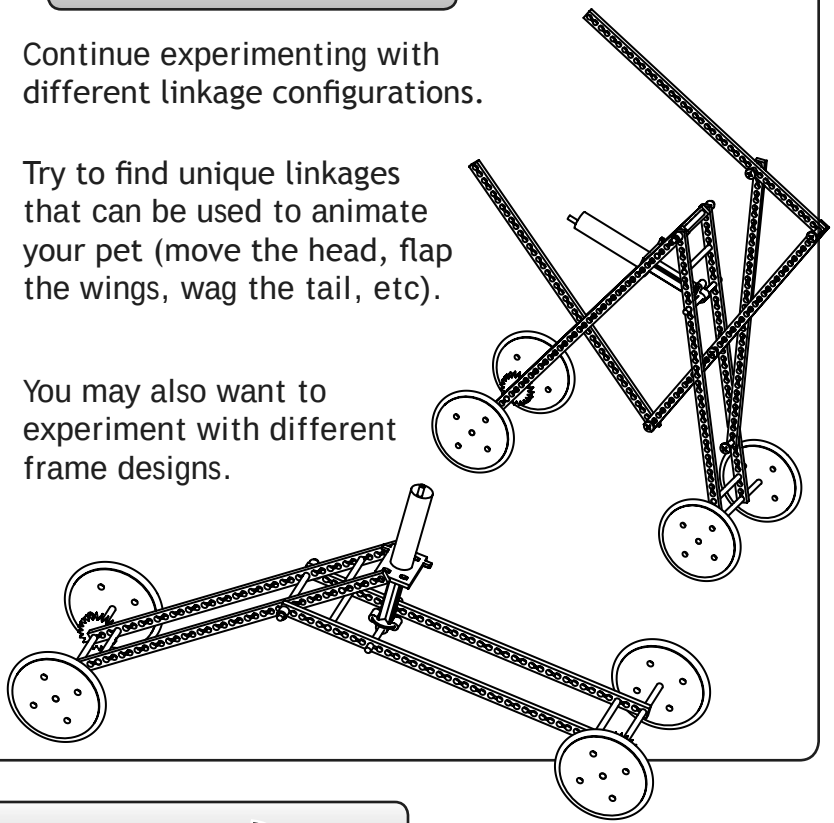
Experiment by changing the length and pivot points of the linkage.

3. Create

Continue experimenting with different linkage configurations.

Try to find unique linkages that can be used to animate your pet (move the head, flap the wings, wag the tail, etc).

You may also want to experiment with different frame designs.

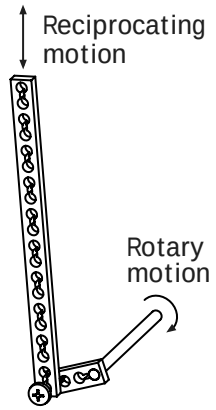


WHAT CAN YOU FIND?

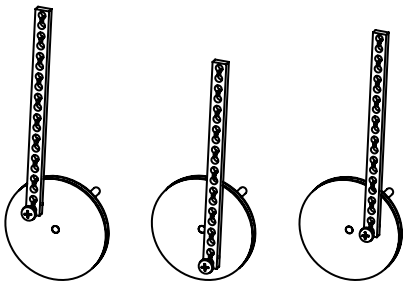
Gather materials that can be used in creative ways on your pet (materials for ears, wings, mouth, tail, gills, feet, teeth, nose, head, etc.).

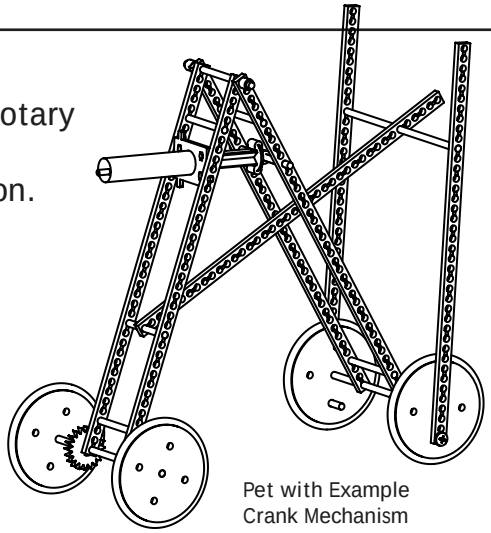
More Mechanisms

The Crank



A crank is a mechanism that changes rotary motion into reciprocating motion, or reciprocation motion into rotary motion.



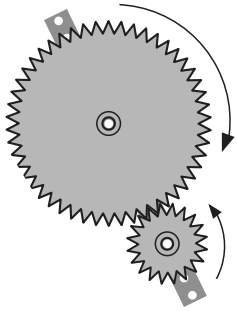


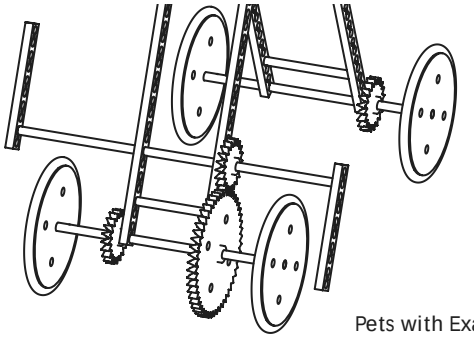
Pet with Example Crank Mechanism

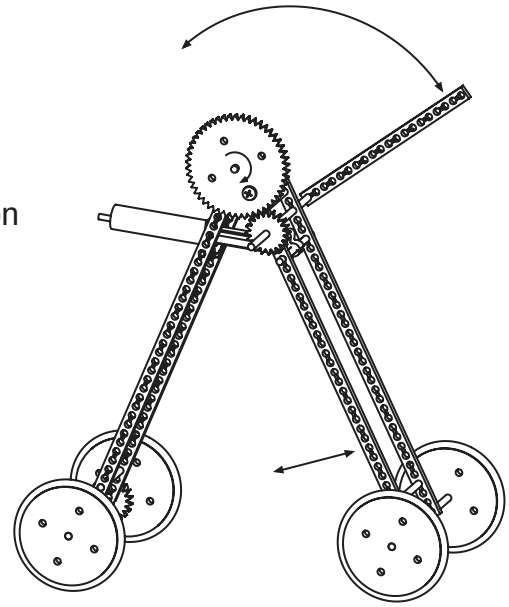
Gears

A gear is a wheel with evenly spaced teeth around its perimeter.

The teeth on multiple gears can mesh to form a gear train. Gear trains (meshing gears) can transmit force, create a mechanical advantage, or change the direction of force.



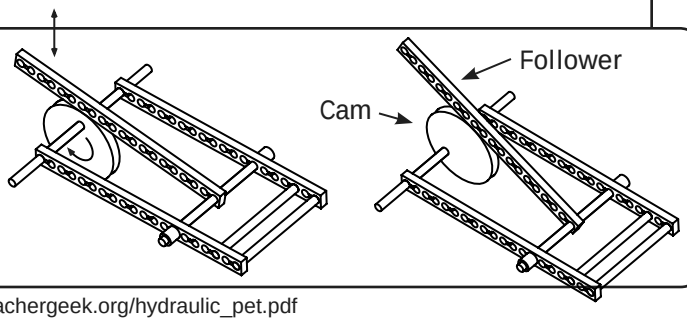




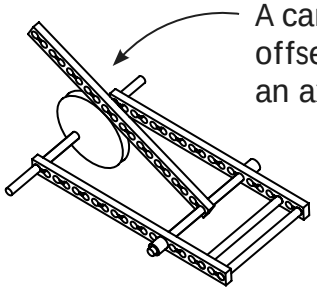
Pets with Example Gear Mechanisms

Cam & Follower

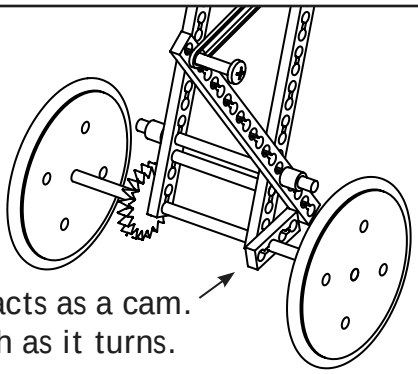
A Cam changes the input motion (rotating motion), to a reciprocating motion of the follower.



Cam & Follower (continued)



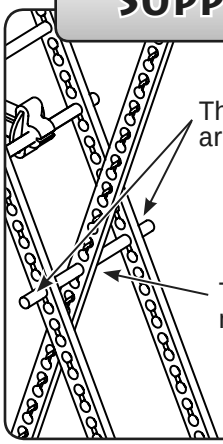
A cam can be created by placing an offset (not centered) component on an axle.



The connector strip on the axle acts as a cam. It pushes the lever back and forth as it turns.

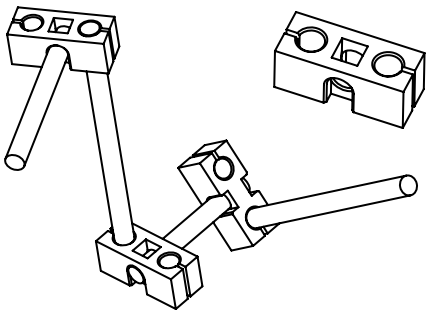
Construction Tips

Support The Axles



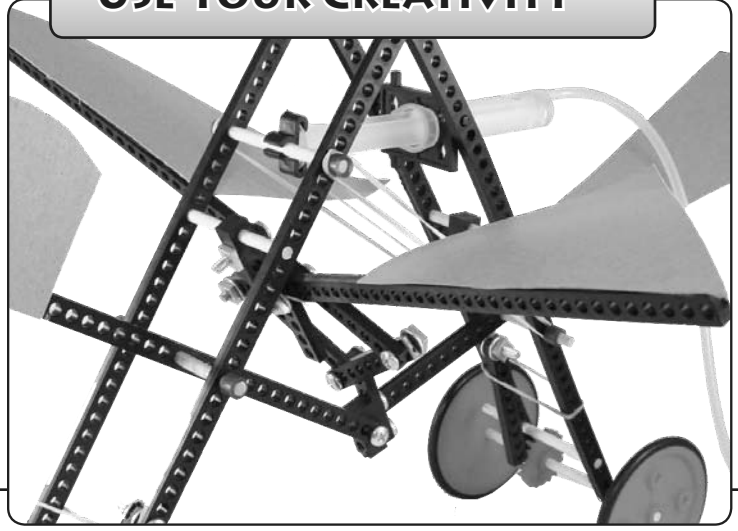
An axle (rotating dowel) is best supported when it sits between two connector strips with reamed holes.

Perpendicular Adaptors



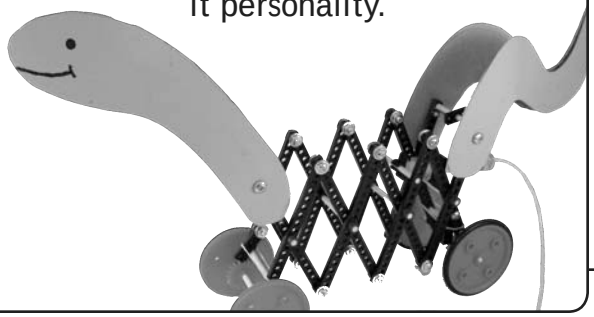
Use perpendicular adaptors to make dowels, connectors strips and other components connect in different directions.

Use Your Creativity



Appearance

Make it look good. Give it personality.



Let's Get Building !!!

You now have the knowledge and experience to design and construct your own unique hydraulic pet. You can do this by modifying or completely reconstructing your example pet.

The Criteria

Remember, your pet should meet the following criteria.

The hydraulic pet should:

- resemble an animal (insect, bird, fish, dog, etc.) or make-believe creature.
- have parts that move in interesting ways when the toy moves (wings that flap, a head that bobs, a mouth that opens and closes, a tail that wags, etc.).
- be hydraulically powered.
- move forwards and move its parts using hydraulic power (it can't be pulled or pushed).
- be as unique and different as possible.
- have a "catchy" name.
- be attractive and well constructed.

Warning: The small parts in this kit are a CHOKING HAZARD for small children. The parts for this activity and final hydraulic pet are not for children under 3 yrs.