JCB JS220
Hydraulic Excavator

An Original LEGO® Creation by Jennifer Clark
Instructions by Eric Albrecht

JCB JS220 Excavator

Concept and History

Excavators can be seen everywhere, ranging from one ton mini excavators digging ditches at the roadside, to monsters weighing thousands of tons in mines and quarries. Most are used for their traditional purpose of removing material from a surface and placing it elsewhere, with the nature and volume of material being excavated, and even the weather conditions, affecting the choice of excavator and digging apparatus used. Nowadays excavators are also employed in other roles such as demolition, where their versatility exceeds that of traditional techniques such as the crane and wrecking ball.

While historical reports claim that excavators were used for canal dredging in ancient Egypt, the genesis of the excavator in the form we recognize today was the Steam Shovel, patented by William Smith Otis in 1839. Steam shovels used a system of pulleys to move their arms and bucket, but otherwise worked on the same principles as the modern hydraulic excavator.

Prior to the advent of the steam shovel, all earth moving, from digging small holes in the ground to civil engineering projects moving thousands of tons of material had to be performed manually

by gangs of laborers. The steam shovel revolutionized the construction and civil engineering industries, bringing projects hitherto impractical into reality - Otis's steam shovel was said to do the work of eighty men.

Excavators were first mounted on caterpillar tracks at the beginning of the 20th Century, soon after the first practical tracked vehicle, the "Caterpillar Tractor" was demonstrated by Benjamin Holt. After 1930, steam engines were generally dropped in favor of more efficient diesel or electric power, both of which remain in use today.

Despite initial teething troubles, hydraulics found acceptance in construction machinery due to their relative simplicity and high power to weight ratio compared with other systems. This development led to the Orenstein & Koppel RH 5, the first production fully hydraulic excavator being introduced in 1961, which to this day defines the form of the modern power excavator.

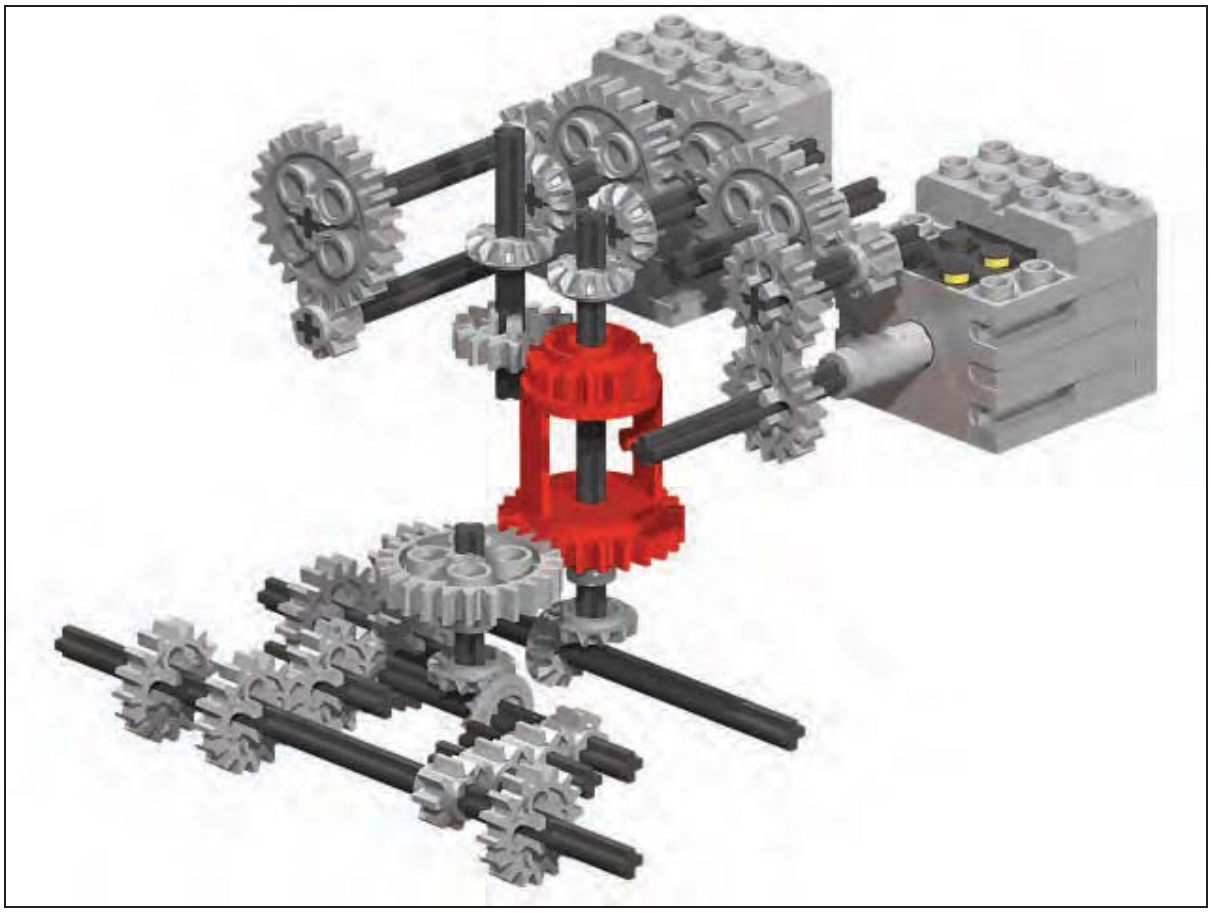
Inspiration

Tracked hydraulic excavators have always been one of my favorite types of construction machinery, and some time ago I built a working Lego model of the seven ton JCB JS70 excavator and documented it on my website. Even while designing this model, however, I was aware of certain limitations, and began forming plans to build an improved version at a later date.

The model worked well enough, but I thought it could be more efficient – there was a lot of friction present in the gears, and consequently the motors had to work very hard for fairly sluggish movements. And while it was a great challenge to model a very small excavator to scale, I thought that building one of its larger siblings at the same scale would present opportunities to overcome these limitations.

I had seen the JS220 on the JCB website and at a distance on building sites, and it really appealed to me – at 22 tons it is neither the smallest nor the largest in the JCB range, which I thought would leave plenty room for working functions. Had I chosen a larger excavator to model I suspect the Lego electric motors and pneumatic parts would have had difficulty moving it effectively.

The JS220 is a crossover machine capable of operating on jobs traditionally done by excavators in both the 20 and 25 ton classes, and its specifications are such that it can be transported on a standard 44 ton gross weight 6 axle articulated lorry in the UK without prior Police notification. Both of these factors make this machine popular in the plant hire sector.



Drive gear arrangements for both tracks on the older JS70 model – the motors are located at the rear of the superstructure. A differential case, shown in red, goes through the center of the turntable (not shown) and acts as the outer shaft for the concentric drive system, eventually leading to the drive sprocket for the left track. The axle going through the center of the red differential case can be driven independently of it and drives the sprocket for the right track.

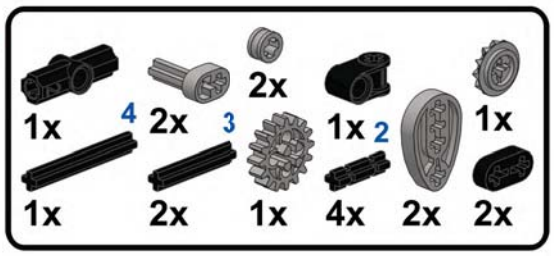
After publishing this model on my website the idea of routing the drive shafts for the tracks through the turntable generated interest amongst some Lego builders, and Thomas Avery went on to build a larger excavator based on this principle with all three motors in the superstructure, thus obtaining infinite slew. While his developments pushed the Lego state of the art forward, I still saw further room for improvement, and was keen to build these improvements into a new model before someone else did!

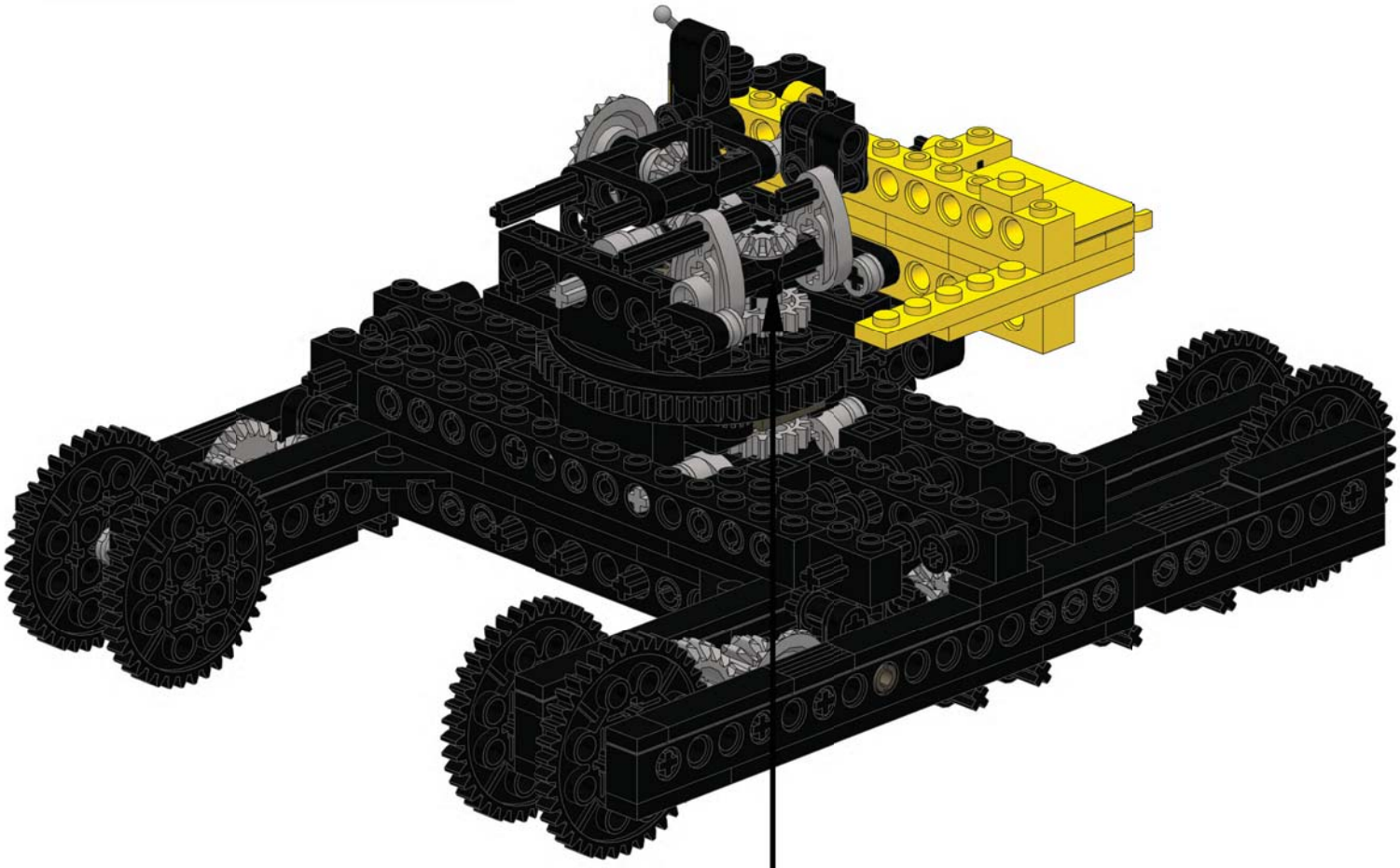
There are a couple of interesting side effects of this method of propulsion. First of all, even if the drive motors in the superstructure have stopped, rotating the superstructure relative to the undercarriage will turn the tracks. As well as making the excavator behave a bit oddly, this causes the slew motor to drive the tracks a little, leaving less power for its primary purpose. Leo Dorst has suggested that a system of differential gears could be used to eliminate this effect, but that is a project for another day and a larger model!

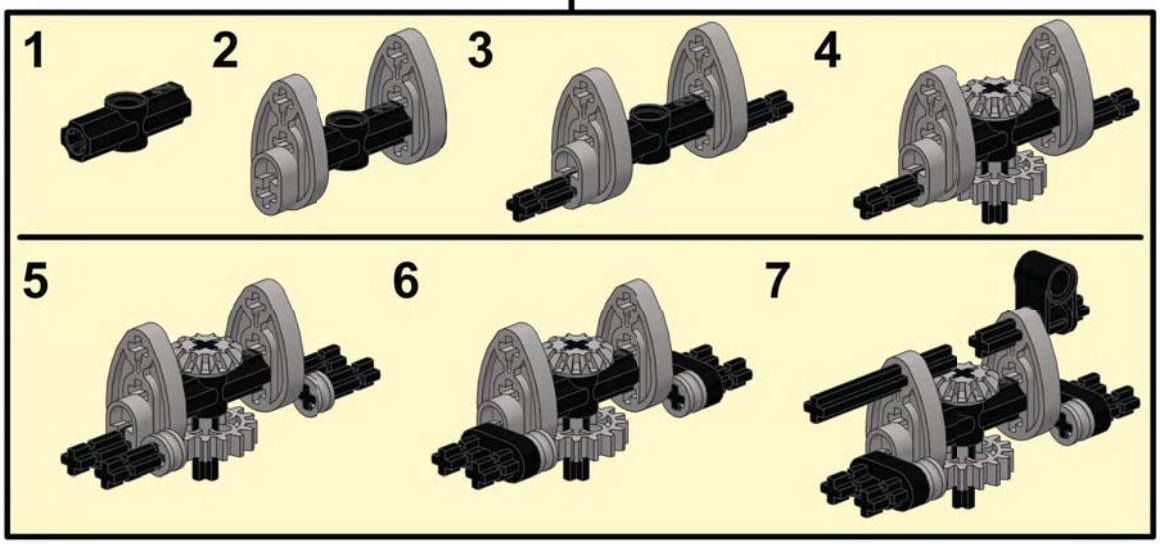
While not entirely removing this effect from this model, I employed a method to reduce its impact significantly. In the JS70 and Thomas Avery's excavator, all of the gear reduction for driving the tracks was in the superstructure before the drive shafts went through the slew ring. With this arrangement, one revolution of the superstructure will rotate the track drive sprocket through one revolution. In this model, however, all gear reduction is performed in the undercarriage *after* the slew ring, and the effect of one rotation of the superstructure is reduced correspondingly. As the total gear reduction is approximately 14:1, the track drive sprocket will move only 1/14 of a revolution for one turn of the superstructure, an improvement to the extent that you only notice the effect if you are really looking for it, whereas on the JS70 it was pretty obvious that something strange was happening. Excavator efficiency is also improved, since the amount of wasted effort from the slew motor driving the tracks has been reduced by a factor of 14.

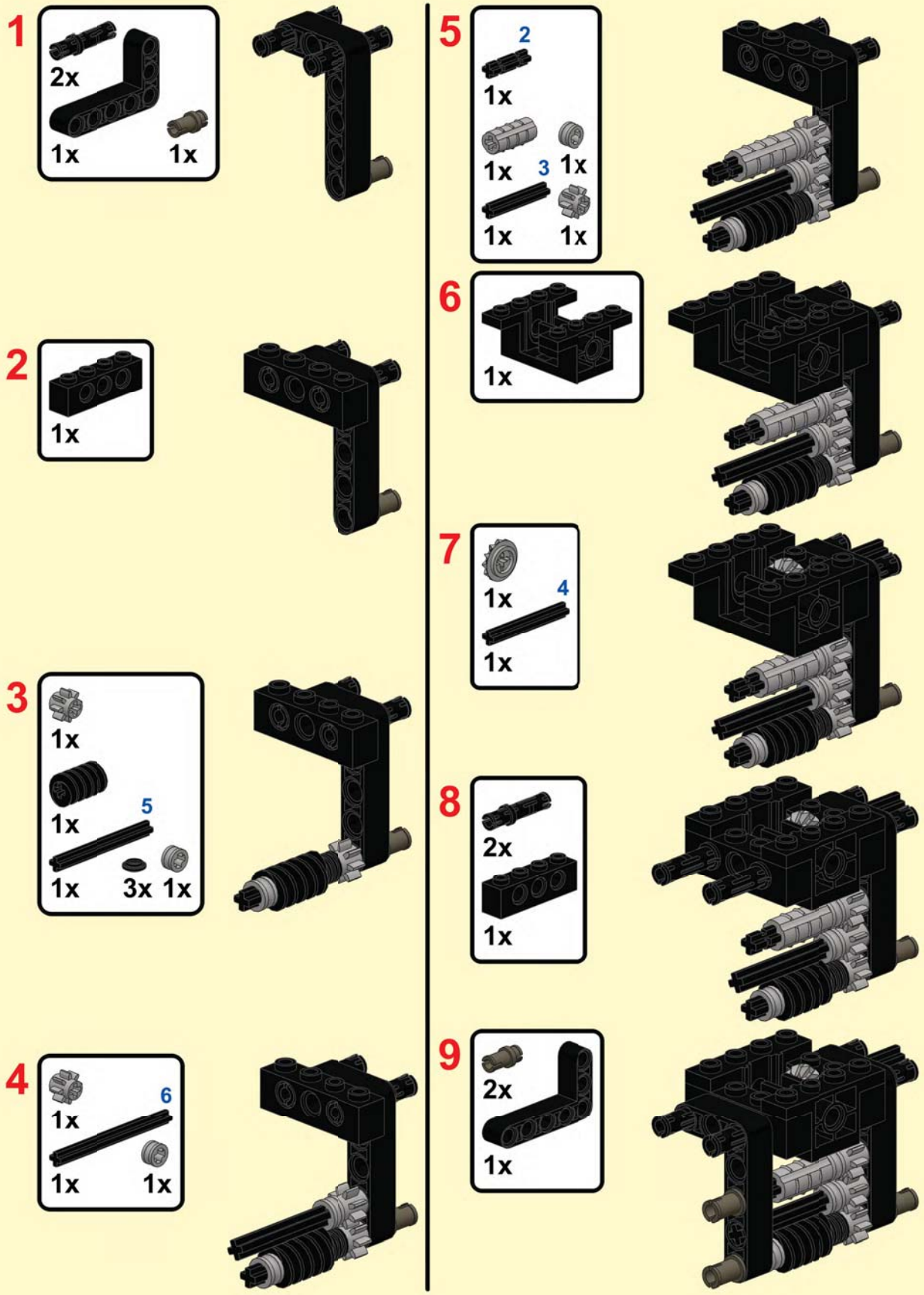
All three motors, one driving each track and another for slewing, are located in the rear of the superstructure. In additional to allowing infinite slew, this also makes them function as effective counterweights, rather than dead weight in the undercarriage.

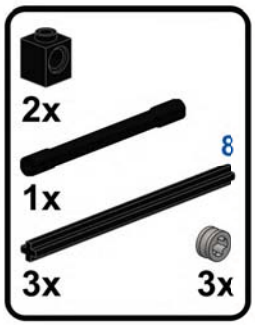
15

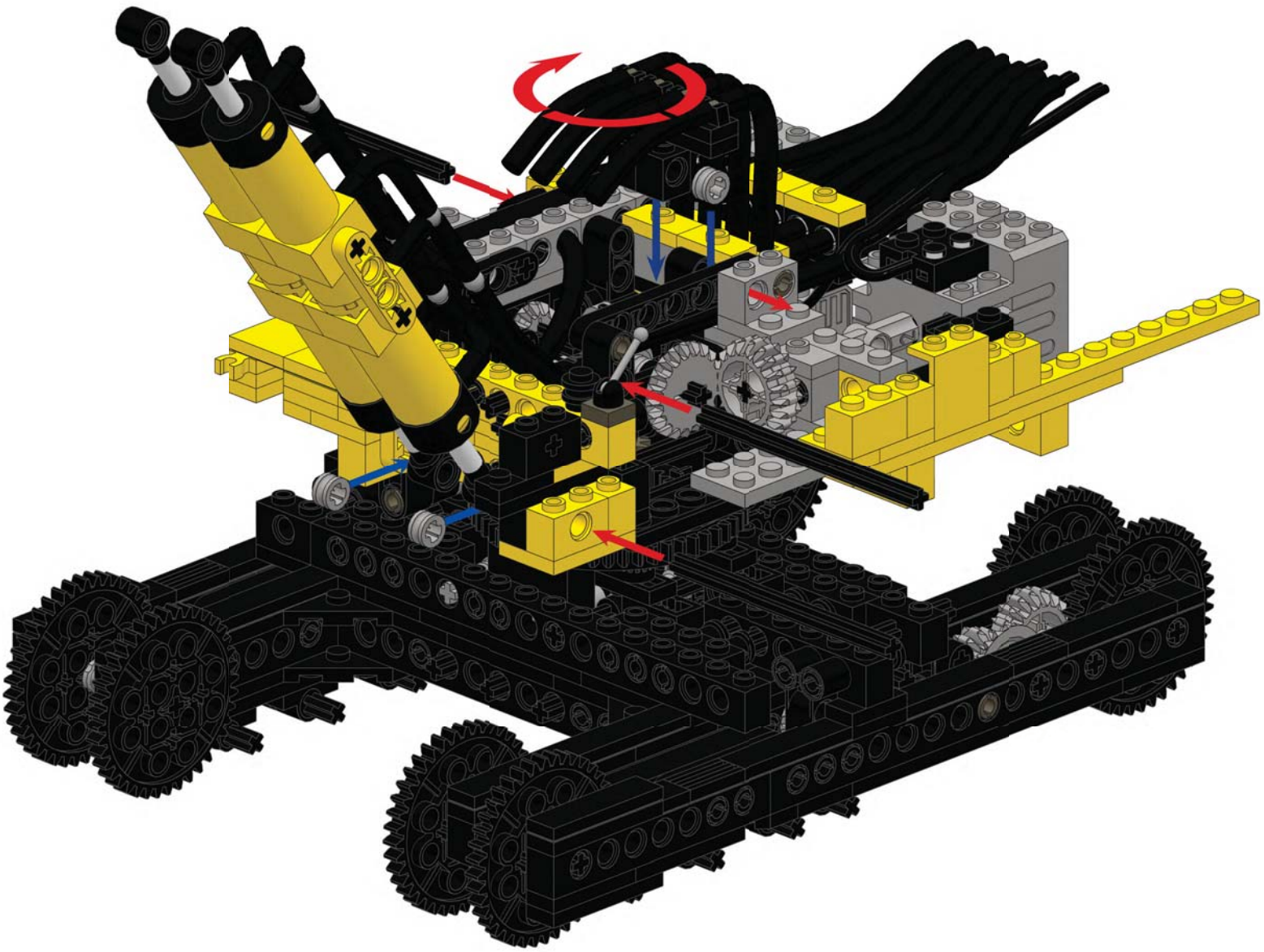




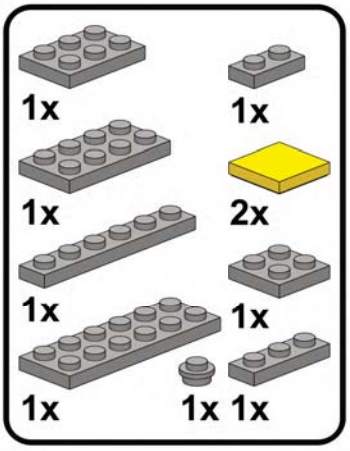


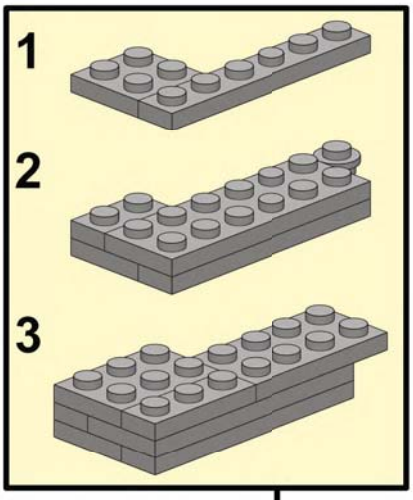


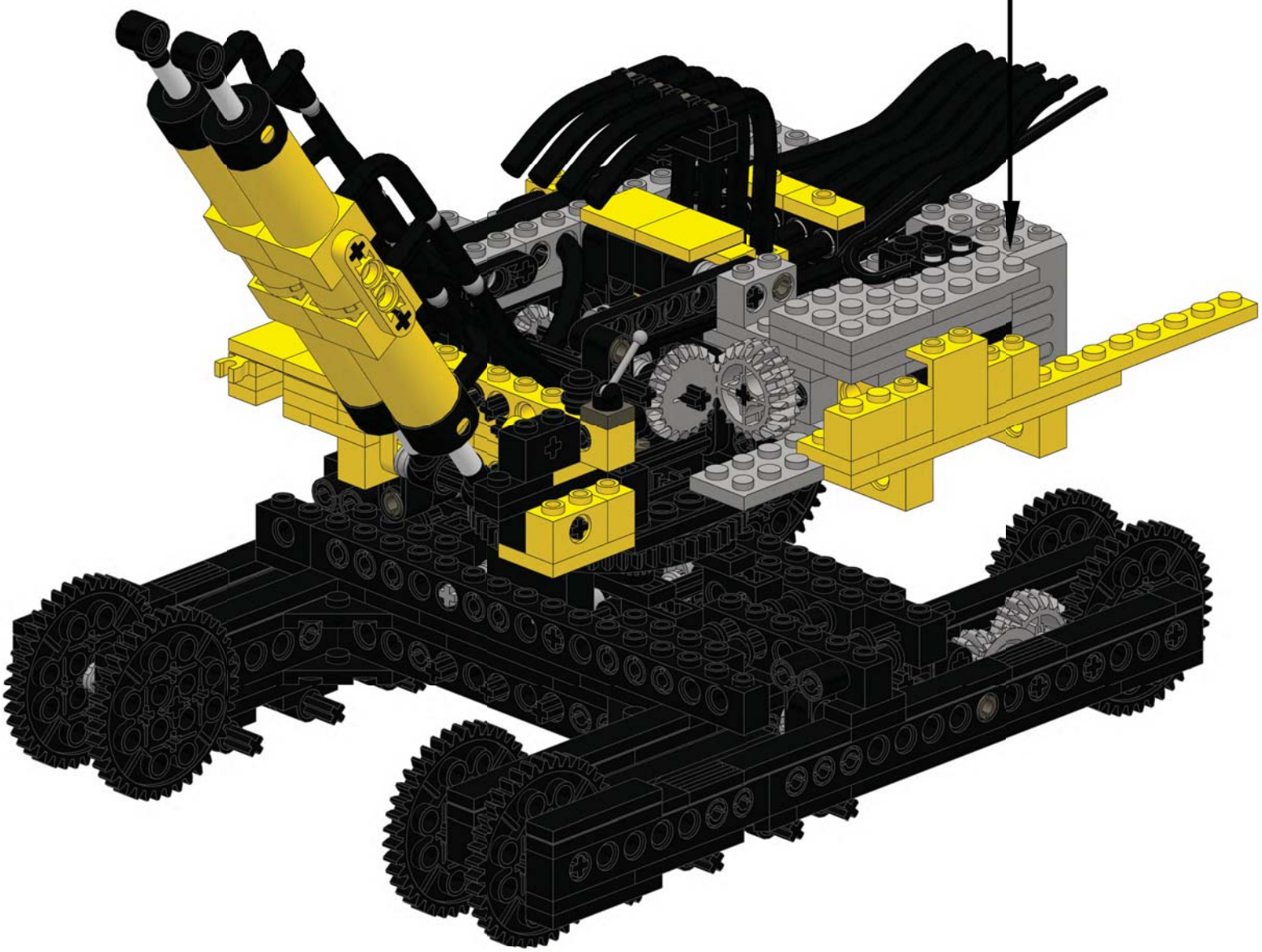




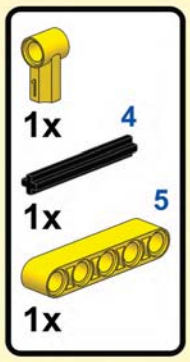
28

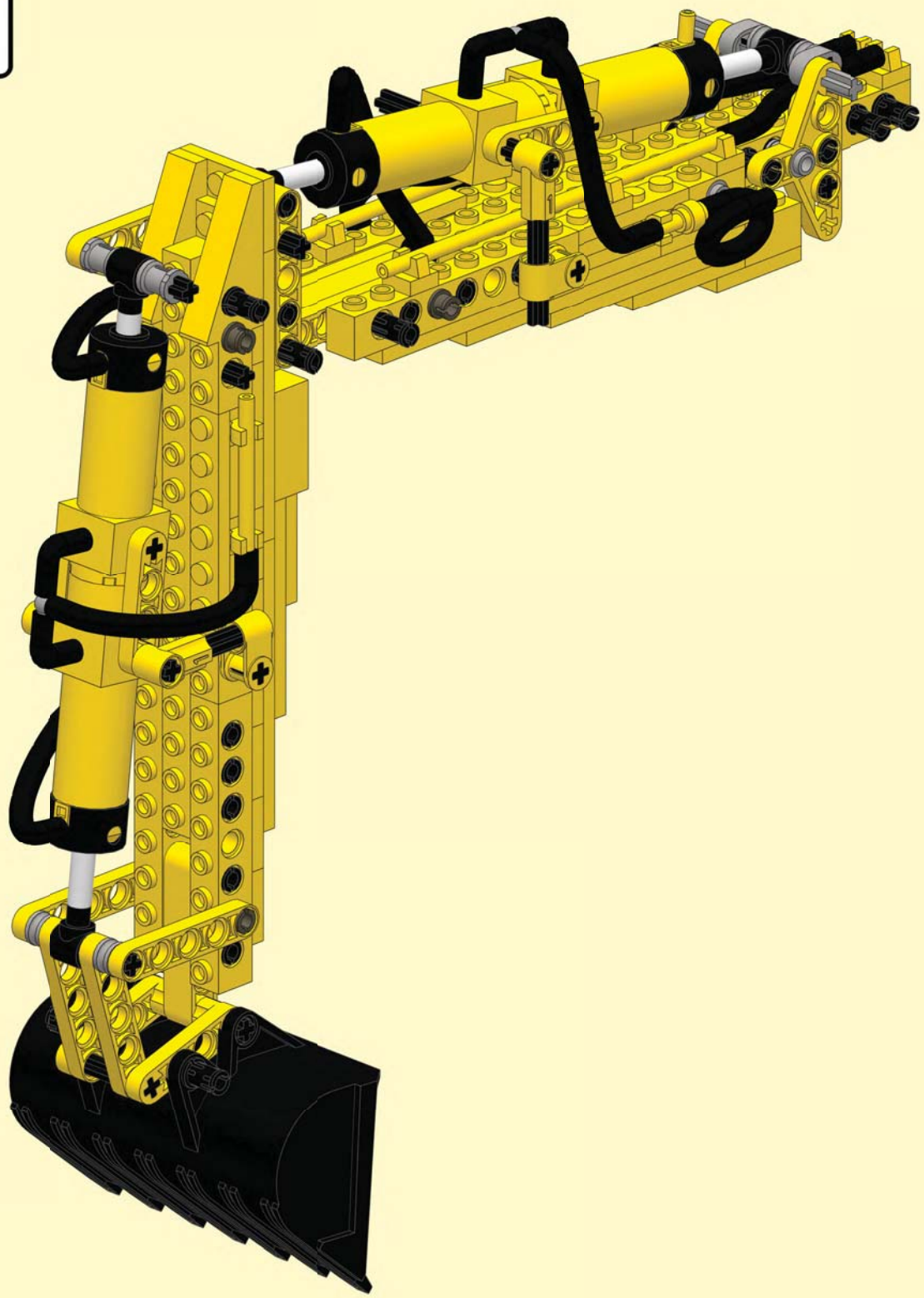




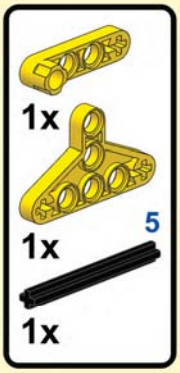


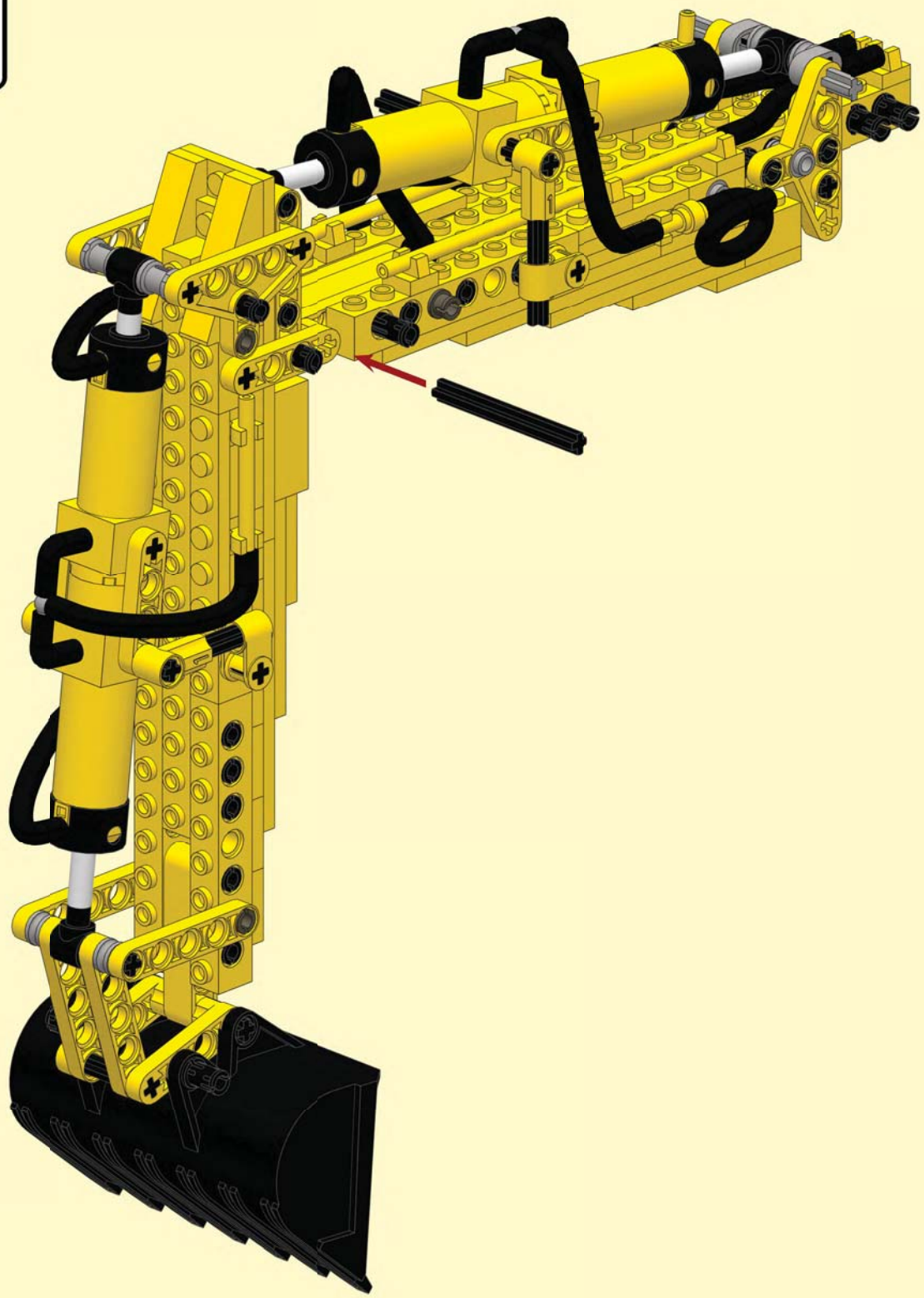
14

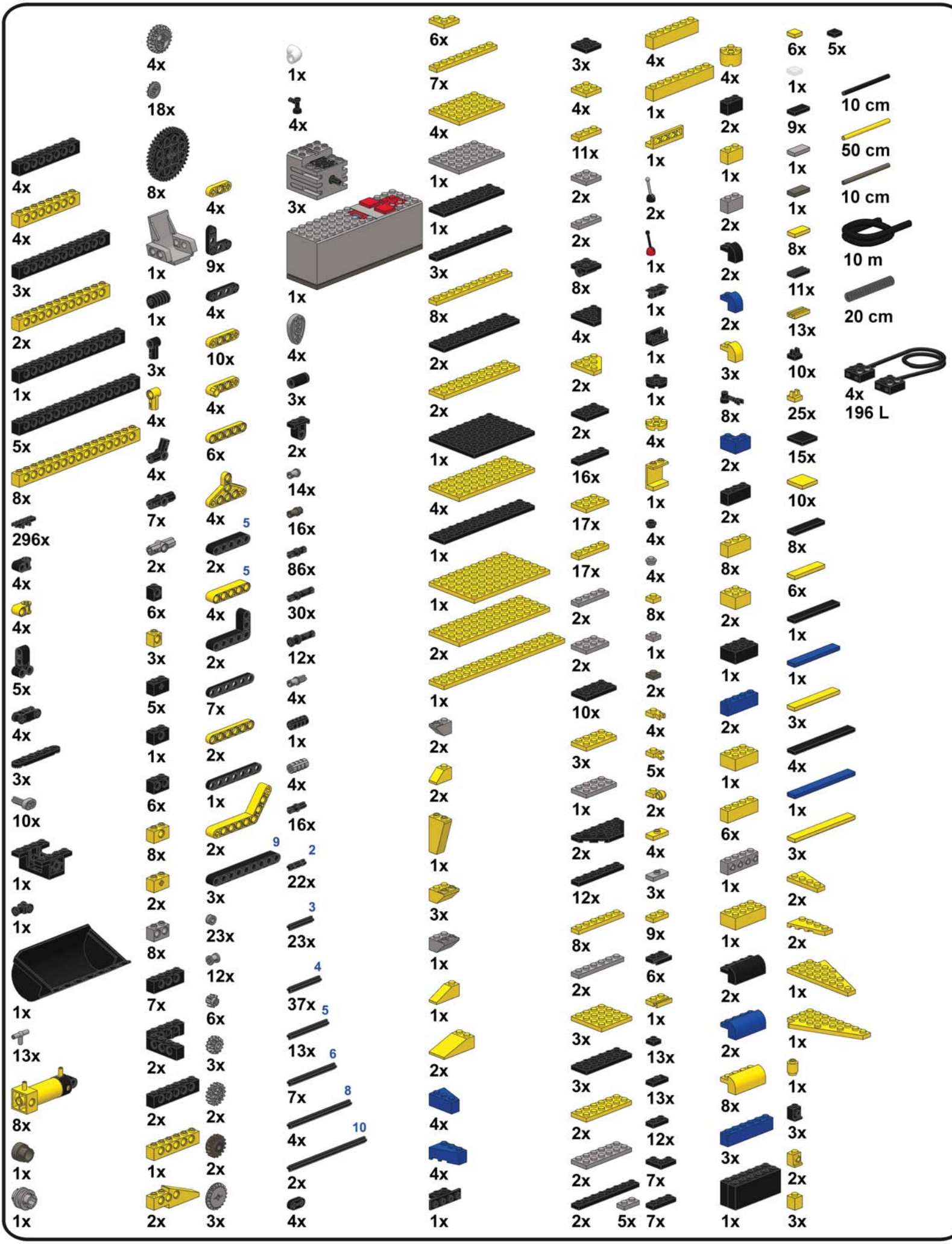


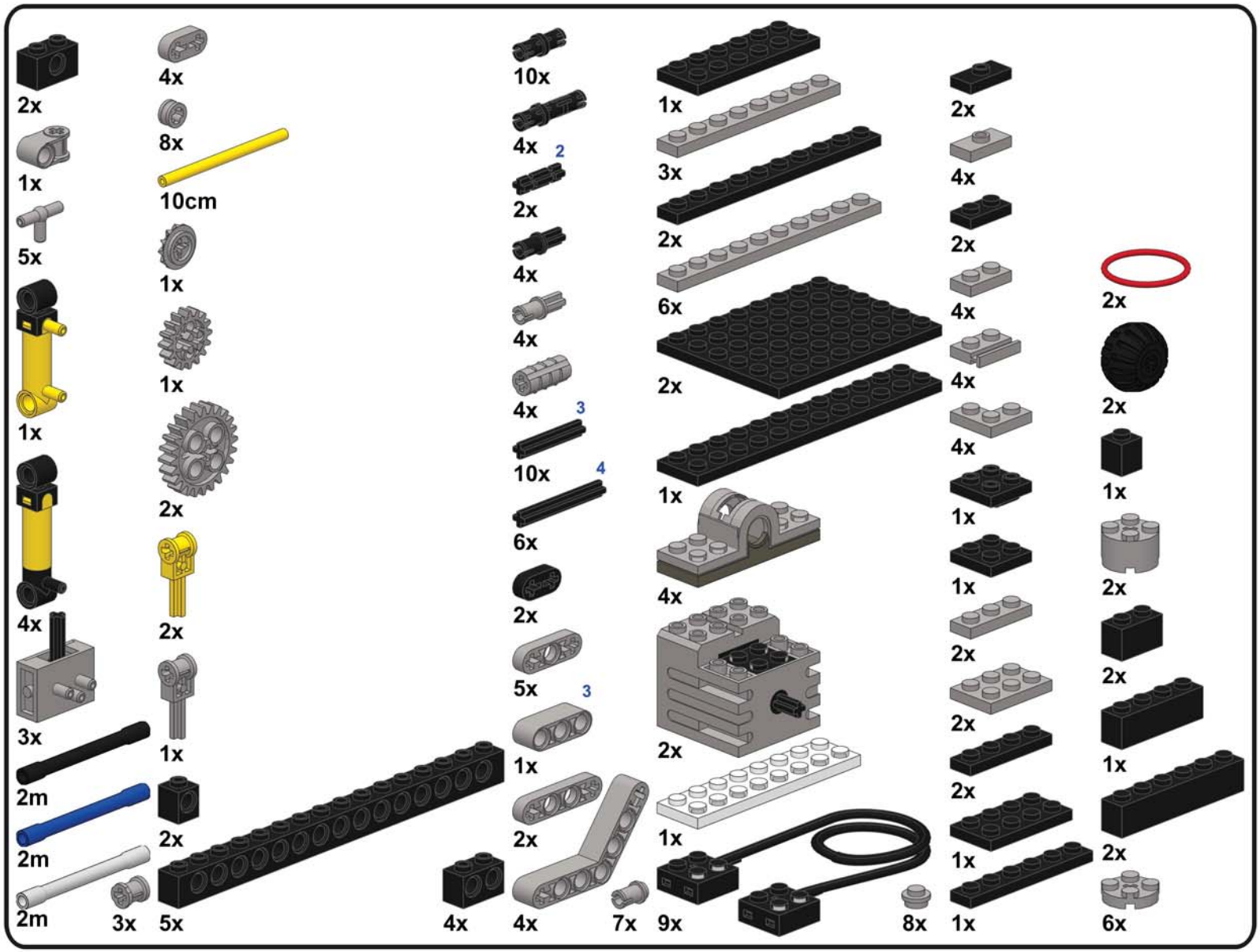


15






4x
4x
3x
2x
1x
5x
8x
296x
4x
4x
5x
4x
3x
10x
1x
1x
1x
13x
8x
1x
1x
4x
18x
8x
1x
1x
3x
4x
4x
7x
2x
6x
3x
5x
1x
6x
8x
2x
8x
7x
2x
2x
1x
4x
9x
4x
10x
4x
6x
4x
2x
4x
2x
7x
2x
1x
2x
23x
12x
6x
3x
2x
2x
3x
1x
4x
1x
4x
3x
16x
86x
30x
12x
4x
1x
4x
16x
22x
23x
37x
13x
7x
4x
2x
4x
6x
7x
1x
3x
1x
1x
2x
4x
4x
1x
3x
4x
11x
2x
2x
8x
4x
2x
2x
16x
17x
17x
2x
2x
10x
3x
1x
2x
12x
8x
2x
3x
3x
2x
2x
2x
5x
7x
4x
1x
2x
4x
2x
1x
2x
4x
8x
1x
2x
4x
5x
2x
4x
3x
9x
6x
1x
13x
13x
12x
7x
7x
4x
2x
2x
1x
6x
5x
1x
9x
1x
1x
8x
11x
13x
10x
25x
15x
10x
8x
6x
1x
1x
3x
4x
1x
2x
2x
1x
2x
2x
2x
2x
2x
3x
8x
2x
2x
8x
2x
1x
2x
2x
1x
6x
1x
2x
1x
2x
8x
3x
1x
2x
3x
1x
10 cm
50 cm
10 cm
10 m
20 cm
4x
196 L


2x
1x
5x
1x
4x
3x
2m
2m
2m
3x
4x
8x
10cm
1x
1x
2x
2x
1x
2x
5x
4x
10x
4x
2
2x
4x
4x
4x
3
10x
4
6x
2x
5x
3
1x
2x
2x
4x
1x
3x
2x
6x
2x
1x
4x
2x
1x
9x
8x
2x
4x
2x
4x
4x
4x
1x
1x
2x
2x
2x
2x
2x
1x
1x
2x
2x
2x
2x
1x
2x
1x
6x