Building clocks using LEGO® Technic

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It may seem almost impossible at first glance, but building working clocks and even calendars using Technic parts is not too difficult. It is well within reach of most builders that have a couple of Technic sets and are ready to perhaps buy a few additional parts. If you are interested, in this article we will provide some useful hints for becoming a LEGO® clockmaker.

Most important and critical three components of a clock are the timing mechanism which provides initial rotation, the mechanism which converts rotation speeds as necessary, and the hand mechanism which rotates the hands. Let us focus on them one by one. (Actually, the hand mechanism may even be ignored if you are content to build a clock with multiple faces).

Initial timing

The initial timing mechanism is actually the most difficult to implement, because our clock — and actually, any mechanical clock in general — relies on it providing a very accurate and stable rotation speed. While rotation poses no problem, stability and accuracy does. Although seemingly always rotating at the same speed, standard Power Functions and other LEGO motors actually noticeably vary their speed. Not only are there slight differences between identical models due to manufacturing tolerances, but also the individual motor speed changes unpredictably as its internal gearbox wears down and increases friction in the long term, while the electric parts heat up and the batteries' power drops in the short term.

You should therefore be aware that a clock relying on standard LEGO motors will probably not be perfectly accurate, nor consistent in its offset. However, if used for demonstration, even adjusting it very roughly (e.g., if its "minute" lasts at least between 50 and 70 seconds, which is easily done) should suffice for a nice effect for the audience.

However, there is still a pure solution for a perfectly accurate clock, indeed useful for measuring real time: Mindstorms™. Regardless of the version you are using, it is fairly simple to make its motor turn a given angle every specific number of seconds. It is far more expensive than just improvising with a standard motor, but it guarantees an accurate clock.

Somewhat pricey, but the only option if you intend to build a really accurate LEGO® clock is to employ some generation of Mindstorms.

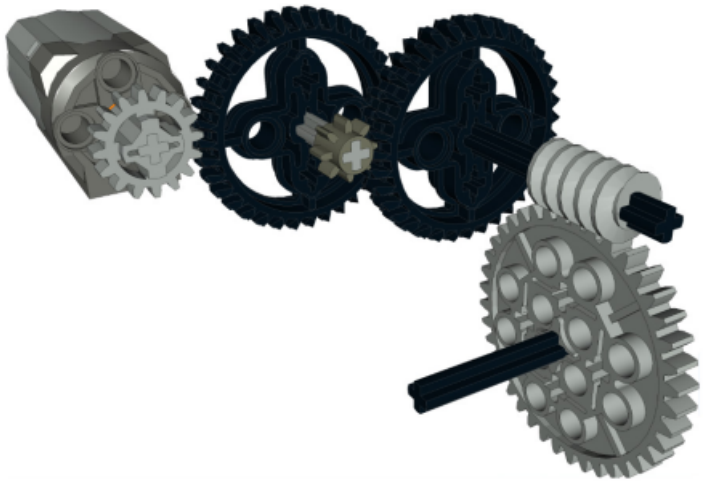
Gearing down

El In the next stage, then, it is required to convert the known input rotation speed to speeds needed in a clock: the hand indicating seconds turns once every minute, the minute hand once an hour, and the hour hand once every 12 hours. Fortunately, this can be easily done using standard, easily accessible gears. The best approach is to use the second-indicating hand as a reference, and gear it down further by required ratios.

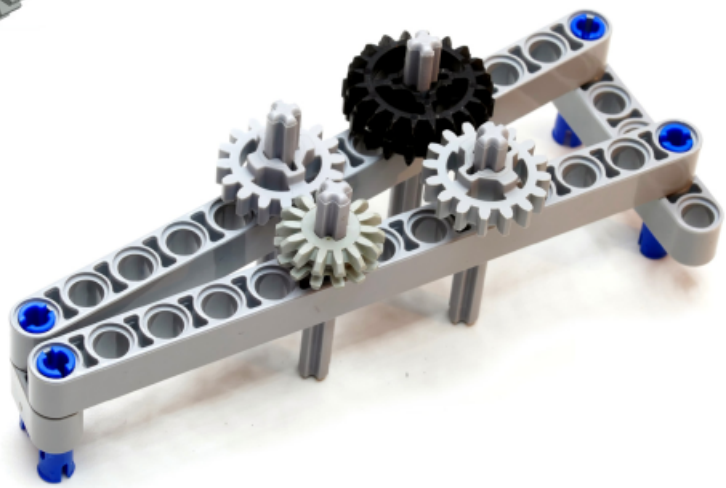
To reduce the rotation speed sixtyfold, which is needed to obtain the speed of the minute hand, two pairs of gears are needed. In one, a reduction of one third is needed which can be done by meshing 8T and 12T, or 16T and 24T, or 24T and 36T gears. In the other, another forty times are reduced by driving a 40T gear with a worm gear. Combining these gear pairs, i.e. multiplying forty by two thirds, yields the required gearing down sixtyfold. Gearing down further from the minute hand to the hour hand is easier: a worm gear can directly drive a 12T gear, or a 24T gear if you prefer to build a full 24-hour clock.

If you want to go a step further and build a calendar as well, it is doable though it requires a rarer gear. To convert hour hand into the hand indicating days of the week, a fourteenfold reduction is required (or sevenfold if using a 24-hour clock). This asks for a slightly older 14T gear (part no.4143), discontinued in 2002 but still easily available through BrickLink, which needs to be meshed with a worm gear, and combined with additional double reduction if needed, which is rather simple (8T-16T, or 12T-24T, or 20T-40T gears). A sixtyfold reduction, needed to indicate the day of the month, relies on the gears used to convert a second hand speed to the minute hand (and halved if required).

If you are familiar with gearboxes, you have certainly noticed that the mentioned gear pairs are mostly not directly meshable using the standard stud-wide lengths and beams. There are multiple methods to mesh them anyway, and this is where some ingenuity is called for. You do not need to over-engineer these mechanisms, because they handle almost negligible torques and forces.



An example of gearing down: using a standard new PF Medium motor, this gearing makes the final 40T gear make approximately one turn per minute, i.e. it serves as a second-indicating clock hand.



Using triangular and skewed structures allows meshing gears that are not possible to mesh directly when connected to a single beam.

Of course, if you are not using a Mindstorms motor adjusted to turn once every minute, there is one more speed reduction to do: from the motor axis down to the second-indicating hand, making a full circle every sixty seconds. As said before, you may need to measure the speed of your specific motor and develop its custom gearbox, though the following table, calculated for the rotation speeds of most common motors, may be a useful starting point:

Motor type	Typical rotation speed	Combination of gear pairs yielding one turn every minute
PF Medium	405 RPM	16T-36T > 8T-36T > Worm-40T
PF Large	390 RPM	14T-16T > 12T-16T > Worm-16T > Worm-16T (Actually 1:390.1)
PF XL	220 RPM	14T-12T > 8T-20T > 14T-36T > Worm-40T (Actually 1:220.4)
2838	4100 RPM	Worm-16T > Worm-16T > Worm-16T (Actually 1:4096)

As you can see, be prepared to build lots of bulky gearboxes, but it is worth the effort!

Coaxial hand movement

The third important stage of a clock is the mechanism allowing the second, minute and hour hands to turn along a common axis, just like on any typical clock. Since there are not too many options, most LEGO clocks employ the idea of an axle, inside a gear changer ring connected to the gearbox gears on both sides, all inside a turntable, or something very similar. This setup allows turning each hand individually via the mechanisms behind, yet all from the same central axis.

Keep in mind that the turntable's outer gear has 56 teeth, and if you intend to drive it with an 8T gear, you will actually need to gear down the minute hand by 7/12 (12 hours x 56 teeth / 8 teeth), which can be obtained by meshing a 14T gear with a 24T gear.

The axle and the turntable are easy to attach the hands to, but the gear changer in the middle may be a little tricky. It is best to connect it to 16T gear (part 6542) and let it rotate a thin plate with toothed ends (part 4262 or similar), or an old-style axle connector (part 4273).

Visual design of the clock and its housing is, of course, another matter — and depends only on your taste. As you see, lots of engineering and diligence is required for a good LEGO clock, but on the other hand, it is a very interesting mechanism to build, and just as fascinating to watch.
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Combining a turntable, a gearbox dogring with toothed gears and a standard axle, it is possible to build three coaxial clock hands, all controlled independently from behind.