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seeing the invisible

The solar system: a escale model

OER ADAPTED TO STUDENTS WITH LOW VISION

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CONTENT

Overview

This is a learning situation in OER format (Open Educational Resource) that provides a series of materials to create in the students the adjusted conception of the sizes and distances between the various bodies of the solar system. One page is provided for each planet or planetary system in addition to another for the Sun, in total 9 pages. In these materials the main planets and satellites are proportionally represented and indicates the scale in meters at which they have to be placed to complete a solar system in which the main star, the planets and their major satellites are located proportionally to scale both size and distance between them.
A space of 70 linear meters is needed to place the actual distances to scale of all the elements. In addition, on the page that collects the data of the Sun, the star closest to the solar system (Proxima Centauri) is represented to scale and the proportional distance to which that star would be located with respect to our scale system is indicated.
The pages corresponding to the Sun and the Jovian and Saturn systems are in A3 format, the rest are in A4 format.
The materials are presented in Spanish, Braille in Spanish and also in English.

Objectives

- Build a scale model of the solar system.
- Understand the true scale of the solar system and its composition.
- Understand scalar calculations.
- Work in a group collecting other complementary data.

Key competences

- Competence in linguistic communication.
- Mathematical competence and competence in science, technology and engineering.
- Digital competence.

Basic knowledge

- Strategies for the search for information, collaboration and communication of scientific processes, results or ideas: digital tools and formatsç frequently used in science (presentation, graph, video, poster, report, etc.).
- Reliable sources of scientific information: recognition and use.
- The answer to scientific questions through experimentation and fieldwork: use of the necessary instruments and spaces (laboratory, classrooms, environment, etc.) in an appropriate way.
- Modeling as a method of representation and understanding of processes or elements of nature.
- The Earth in the universe.
- The origin of the universe and the solar system.
- Components of the solar system: structure and characteristics

Evaluation criteria

- Develop strategies to search for information.
- Collaboration and group communication of scientific processes, results, or ideas
- Use of digital tools to search for information, perform calculations and obtain products.
- Find, recognize and use reliable sources of scientific information.
- Respond to scientific questions through fieldwork using instruments and necessary spaces in an appropriate way.
- Develop models as a method of representation and understanding of processes or elements of nature.
- Understanding the real situation of the Earth in the universe.
- Understand the components of the solar system: structure and characteristics.

User Guide

To build the scale model of the solar system, the materials can be printed on various supports, the simplest is on paper, but it would be more effective on another less fragile support (plastic, wood, metal) that even allows a longer duration in the scale points that correspond to them.

Braille materials allow printing in a fuser oven to be able to have them in relief, using a normal printer and the special paper for this type of oven.

Among the materials provided (in English and English Braille) the appropriate ones will be selected to build the scale model of the solar system. The objective is to build one using a diaphanous space that allows an uninterrupted vision / circulation and in a straight line of at least 70 meters, to place the proportioned elements at the corresponding distance.

Recommendations

The printing process can become part of the student activity.

In addition to the materials provided, students can be asked to work on new ones both to incorporate into the three-dimensional scale model, and only to work in class in a complementary way due to its small scalar size. These new materials/activities will be able to refer both to the planets and satellites as well as to other elements of the solar system such as the circle of asteroids, the dwarf planets, the Kuiper belt, the Oort cloud, minor satellites and Trojans, Lagrange points, comets ... Thus, being able to develop skills related to the search and processing of information, recognize reliable sources, development of mathematical calculations and the corresponding scales.

The classroom can be divided into working groups that are responsible for each of the parts of the scale model. They must understand the overall idea and the various actions and parts necessary for its construction. They

may pose complementary challenges with special characteristics of each planet or astronomical object that each group takes care of.

Methodological aspects

In the realization of these materials, we have taken into account the pedagogical methodologies, which must also be taken into account in their implementation:

- Learning by doing: learning by building models.
- Challenge-Based Learning (ABR): problem solving by posing challenges to obtain an end result.
- Peer tutoring: in the heterogeneous groups of students that are formed, coordinated work will be done so that some students can tutor others.
- Cooperative learning: developed with the common goal that everyone learns and acquires new competencies while benefiting from the exchange of ideas and skills.

Timing

The timing from the materials of this OER, can occupy from a minimum of one session of one hour that allows the construction of the scale model, to several sessions depending on the complementary activities that may arise to develop and learn new skills related to various sciences.

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Planets of the solar system: measurements and correspondence with the model

Planet	Symbol	Equatorial diameter (km)	Mean orbital radius (UA)	Mean orbital radius (km)	Proportional mean orbital radius (m)	Proportional equatorial diameter (mm)	Orbital period (years)	Rotation period (days)	Number of satellites
Sun	☉	1 391 016				216.529		27	
Mercury	☿	4 878	0.39	58 343 170	0.91	0.759	0.24	58.6667	0
Venus	♀	12 100	0.72	107 710 467	1.68	1.884	0.615	243	0
Earth	⊕	12 756	1	149 597 871	2.33	1.986	1	1	1
Mars	♂	6 787	1.52	227 388 763	3.54	1.056	1.88	1.03	2
Jupiter	♃	142 984	5.2	777 908 928	12.11	22.257	11.86	0.414	19
Saturn	♄	120 536	9.54	1 427 163 686	22.22	18.763	29.46	0.426	82
Uranus	♅	51 108	19.19	2 870 783 139	44.69	7.956	84.01	0.718	27
Neptune	♆	49 538	30.06	4 496 911 993	70.00	7.711	164.79	0.6745	14

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Planetary satellites of the solar system: measurements and correspondence with the model

	Equatorial diameter (km)	Mean orbital radius (UA)	Proportional mean orbital radius (mm)	Proportional equatorial diameter (mm)	Orbital period (days)	Orbital perimeter (km)	Orbital speed (km/s)
EARTH-MOON SYSTEM							
Moon	3 476	384 403	59.837	0.541	27.3215	2 415 281	1.02
JOVIAN SYSTEM							
Io	3 643	421 800	65.658	0.567	1.769	2 650 254	17.34
Europe	3 122	671 100	104.465	0.486	3.551	4 216 656	13.74
Ganymede	5 262	1 070 400	166.621	0.819	7.155	6 725 537	10.88
Callisto	4 821	1 882 700	293.066	0.750	16.69	11 829 381	8.20

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	Equatorial diameter (km)	Mean orbital radius (UA)	Proportional mean orbital radius (mm)	Proportional equatorial diameter (mm)	Orbital period (days)	Orbital perimeter (km)	Orbital speed (km/s)
SATURN SYSTEM							
rings	153 000	from 74 500 to 136 800 km from the centre of the planet	21.295	42.589			
			11.597	23.194			
Thetis	1 060	294 619	45.861	0.165	1.888	1 851 150	11.35
Dione	1 118	377 420	58.750	0.174	2.737	1 185 703	5.01
Rhea	1 528	527 040	82.040	0.238	4.518	1 655 749	4.24
Titan	5 150	1 221 850	190.196	0.802	15.495	3 838 564	2.87
Iapetus	1 436	3 561 300	554.360	0.224	79.33	11 188 180	1.63
URANUS SYSTEM							
Ariel	1 158	191 020	29.735	0.180	2.5203	600 108	2.76
Umbriel	1 169	266 300	41.453	0.182	4.1442	836 608	2.34
Titania	1 578	435 910	67.855	0.246	8.7059	1 369 455	1.82
Oberon	1 523	583 519	90.832	0.237	13.4632	1 833 183	1.58
NEPTUNE SYSTEM							
Triton	2 707	354 760	55.223	0.421	-5.88	1 114 514	-2.19

SCALE MODEL OF THE SOLAR SYSTEM

The solar system is made up of the central star, the Sun, and the eight planets we know of: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The planets revolve around the Sun in elliptical orbits.

Their satellites revolve around most of the planets. Only Mercury and Venus lack satellites. These can be of very different sizes. In addition to the planets, other smaller objects also revolve around the Sun: dwarf planets like Pluto or Ceres, a multitude of asteroids that form a belt around the Sun between the orbits of Mars and Jupiter, comets, etc. Asteroids range in size from small stones to huge rocks like mountains. Sometimes they share orbits with the planets, they are called Trojans. Comets have very elongated orbits and come from regions very far from the Sun such as the Kuiper belt or the Oort Cloud almost a light year away.

In the following sheets, the Sun, the planets and their main satellites (those with more than 1000

km in diameter) are represented to scale. Next to the name of the planetary system appears the traditional symbol of the planet. Satellites barely perceptible to scale are marked with dates and are located in proportion to their distance from the respective planet. In turn, each sheet indicates at what real distance it should be placed from the sheet of the Sun, to represent the distances between it and the various planets on a scale. The total distance would be 70 meters. Next to each body, its main data is indicated. The directions of rotation are marked by an arrow indicating the direction of rotation looking from the north pole of the planet. Almost all spin counterclockwise. When they spin clockwise, it is called a retrograde spin. The first sheet represents the Sun and the planets to scale, as well as the closest star to the solar system (Próxima Centauri) and the scalar distance at which it is located.

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SUN

G2 type star (yellow) in the main sequence. It has about 4 600 million years old.

Diameter:
1 391 016km

Rotation period:
±25 days

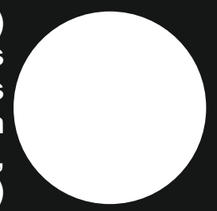
Distance to the galactic center:
26 000 light-years

Galactic orbital period:
200 million years

Mean orbital velocity:
251 km/s

PLANETS TO SCALE:

Closest star: PROXIMA CENTAURI (red dwarf)
in the constellation Centaurus next to the Southern Cross
Distance: 4.22 light-years = 1.295 parsecs
Diameter: 0.29 ± 0.0112 that of the Sun = ± 200 000 km
Distance at this scale = 6 214 km (from Paris for example to Washington DC, Uganda, India, or 1 600 km beyond the North Pole)



SCALE: 15.5 mm = 100 000 km

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MERCURY

Equatorial diameter: 4 878 km

Orbital radius (mean distance from the Sun):
0.39 AU = 58 343 170 km

Rotation period: 58.66 days

Orbital period: 87.97 days

Mean orbital velocity: 47.8 km/s

It has no satellites

[Place 91 cm from the Sun]
15.5 mm
SCALE:
100 000 km

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VENUS

Equatorial diameter: 12 103km

Orbital radius (mean distance from the Sun):
0.72 AU = 108 208 930 km

Rotation period (retrograde):
-243.02 days

Orbital period: 224.7 days

Mean orbital velocity: 35 km/s

It has no satellites

[Place 1.68 m from the Sun]
15.5 mm
SCALE:
100 000 km

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EARTH-MOON SYSTEM

MOON:

Equatorial diameter: 3 476 km

Mean orbital radius: 384 403 km

Orbital and rotation period: 27.32 days

Average orbital speed: 1 km/s

EARTH

equatorial diameter: 12 756km

Orbital radius (mean distance from the Sun):
1 AU = 149 587 870 km

Rotation period: 1 day

Orbital period: 365.25 days

Mean orbital velocity: 29.78 km/s

1 satellite

[Place 2.33 m from the Sun]

15.5 mm

SCALE:

100 000 km

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MARS

Equatorial diameter: 6 794.4km

Orbital radius (mean distance from the Sun):
1.52 AU = 227 936 640 km

Rotation period: 24.62 hours

Orbital period: 686.97 days

Mean orbital velocity: 24.08 km/s

2 satellites (Deimos and Phobos)

[Place 3.54 m from the Sun]
15.5 mm
SCALE:
100 000 km

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JOVIAN SYSTEM

GANYMEDE:

Equatorial diameter: 5 262 km

Mean orbital radius: 1 070 400 km

Orbital and rotation period: 7.1 days

Average orbital velocity: 10.8 km/s

IO:

Equatorial diameter: 3 643 km

Mean orbital radius: 421 800 km

Orbital and rotation period: 1.7 days

Average orbital speed: 17.3 km/s

CALISTO:

Equatorial diameter: 4 821 km

Mean orbital radius: 1 882 700 km

Orbital and rotation period: 16.6 days

Average orbital speed: 8.2 km/s

EUROPE:

Equatorial diameter: 3 122 km

Mean orbital radius: 671 100 km

Orbital and rotation period: 3.5 days

Average orbital speed: 13.7 km/s

JUPITER

Equatorial diameter: 142 984 km

Orbital radius (mean distance from the Sun):
5.2 AU = 777 908 928 km

Rotation period:
9 hours 55 minutes 30 seconds

Orbital period:
11 years, 315 days 1.1 hours

Mean orbital velocity:
13.06 km/s

79 satellites

[Place12.11 m from the Sun]
15.5 mm
SCALE:
100 000 km

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SATURN SYSTEM

REA:

Equatorial diameter: 1 528 km

Mean orbital radius: 527 040 km

Orbital and rotation period: 4.5 days

Average orbital velocity: 4.24 km/s

TETIS:

Equatorial diameter: 1 060 km

Mean orbital radius: 294 619 km

Orbital and rotation period: 1.88 days

Average orbital velocity: 11.35 km/s

TITAN:

Equatorial diameter: 5 150 km

Mean orbital radius: 1 221 850 km

Orbital and rotation period: 15.49 days

Average orbital velocity: 2.87 km/s

DIONE:

Equatorial diameter: 1,118 km

Mean orbital radius: 377,420 km

Orbital and rotation period: 2,737 days

Average orbital velocity: 5.01 km/s

MAIN SYSTEM OF RINGS:
Maximum diameter: 272 000 km
Minimum distance to the equator: 14 232 km
Maximum distance to the equator: 76 532 km
Thickness: from a few meters to ± 1 km

SATURN

Diameters:
equatorial 120 536 km
polar 108 728 km

Orbital radius (mean distance from the Sun):
9.54 AU = 1 426 725 400 000 km

Rotation period:
10 hours 33 minutes 38 seconds

orbital period:
29 years, 167 days and 6.7 hours

mean orbital velocity:
9.67 km/s

82 satellites

[Place 22.22 m from the Sun]

15.5 mm

SCALE:

100 000 km

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URANUS SYSTEM

TITANIA:

Equatorial diameter: 1 578 km

Mean orbital radius: 435 910 km

Orbital and rotation period: 8.70 days

Average orbital speed: 1.82 km/s

UMBRIELD:

Equatorial diameter: 1 169 km

Mean orbital radius: 266 300 km

Orbital and rotation period: 4.14 days

Average orbital velocity: 2.34 km/s

OBERON:

Diameter: 1 523 km

Mean orbital radius: 583 519 km

Orbital and rotation period: 13.46 days

Average orbital speed: 1.58 km/s

ARIEL:

Diameter: 1 158 km

Mean orbital radius: 191 020 km

Orbital and rotation period: 2.52 days

Average Orb Speed: 2.76 km/s

URANUS

Equatorial diameter: 51 108km

Orbital radius (mean distance from the Sun): 19.19 AU = 2 870 783 139 km

Rotation period: -17 hours 14 minutes (retrograde)

Orbital period: 30 799.09 days = 84.32 years

Mean orbital velocity: 6.81 km/s

27 satellites

[Place 44.69 m from the Sun]

15.5 mm

SCALE:

100 000 km

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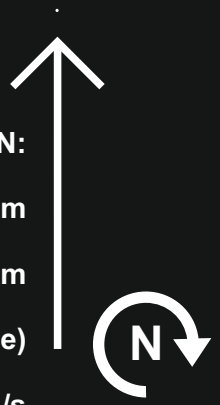
NEPTUNE SYSTEM



TRITON:

Equatorial diameter: 2 707 km

Mean orbital radius: 354 760 km

Orbital and rotation period: -5.87585 days (retrograde)

Average orbital speed: 2.19 km/s

NEPTUNE

equatorial diameter: 49 538km

Orbital radius (mean distance from the Sun): 30.06 AU = 4 498 252 900 km

Rotation period:
16 hours 6 minutes 14 seconds

Orbital period:
60 190 days = 164.79 years

Mean orbital velocity: 5.47 km/s

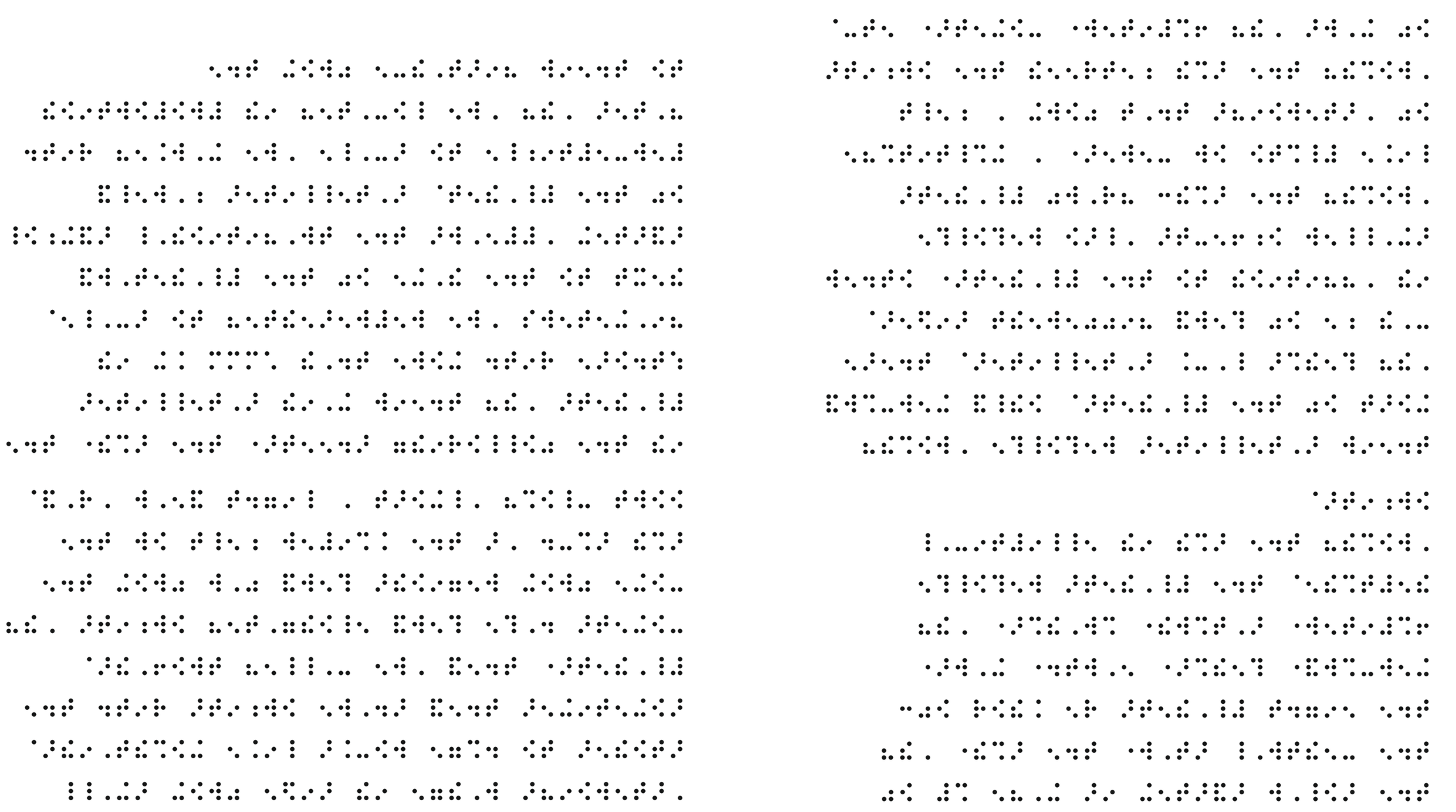
14 satellites

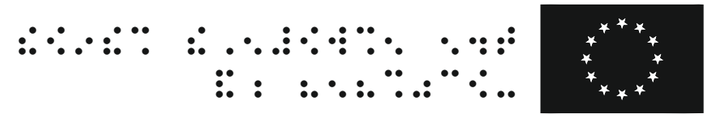
[Place 70 m from the Sun]

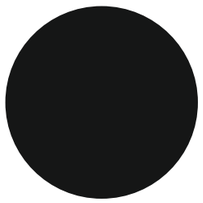
15.5 mm

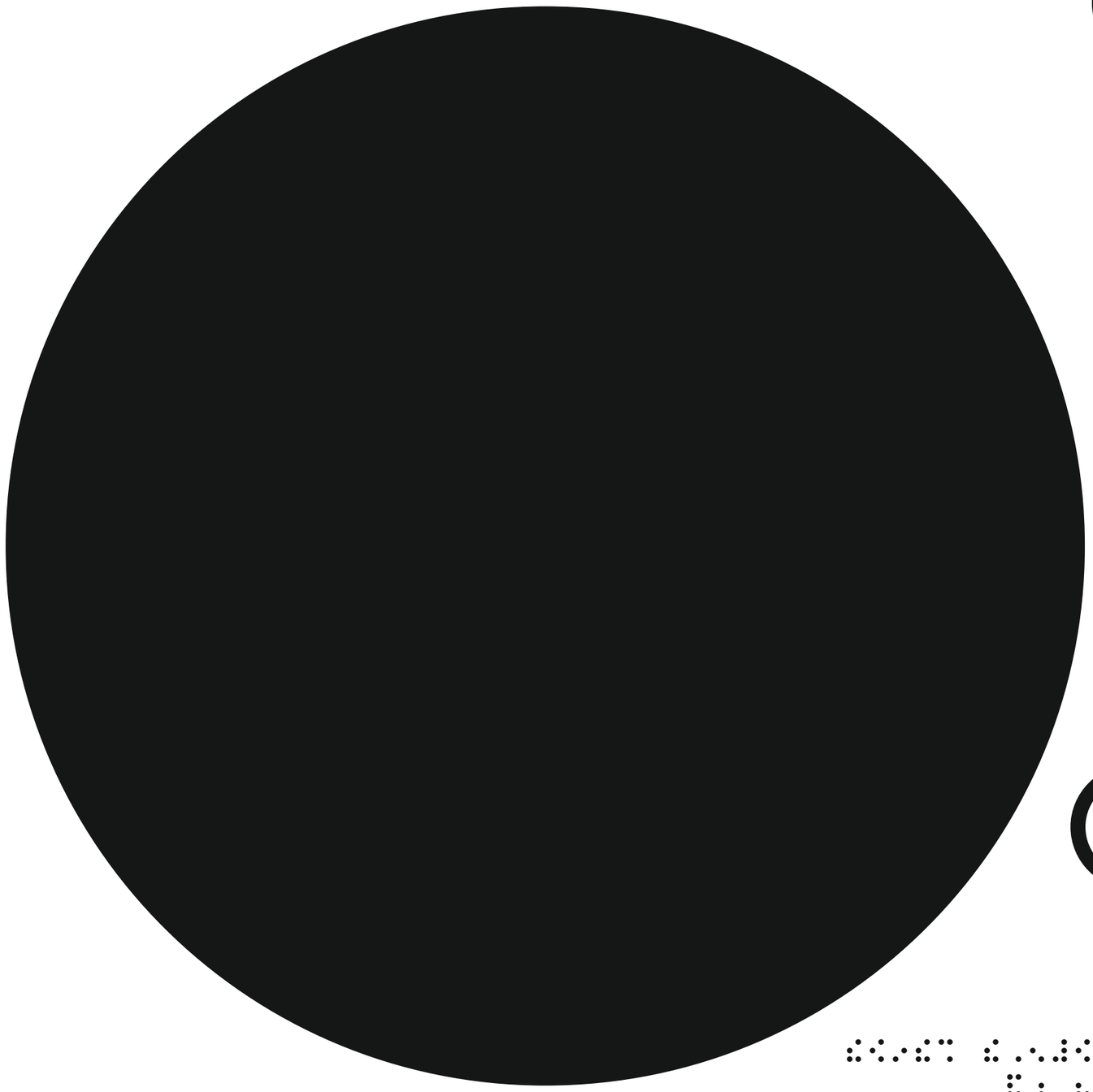
SCALE:

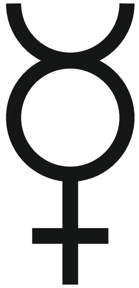
100 000 km

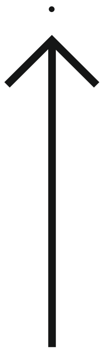












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earth-moon system

moon:

equatorial diameter: 3 476 km

mean orbital radius: 384 403 km

orbital rotation period: 27.32 days

average orbital speed: 1 km/s

earth

equatorial diameter: 12 756 km

orbital radius (mean
from the sun):
1 au = 149 597 870 km

rotation period: 1 day

orbital period: 365.25 days

average orbital velocity:
29.78 km/s

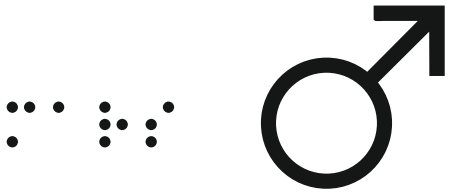
1 satellite (moon)

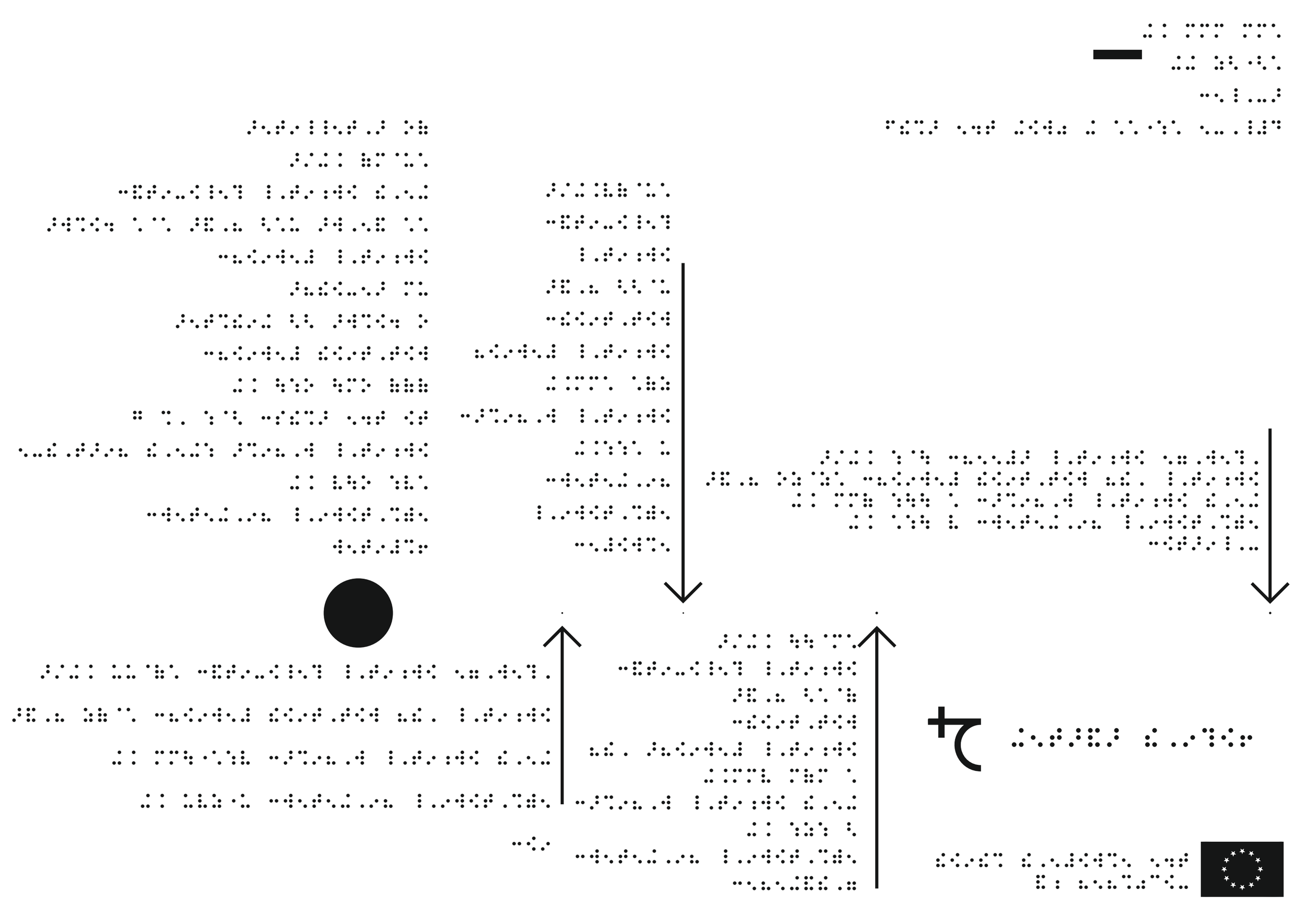
“place ⠣⠄33 m from the sun”

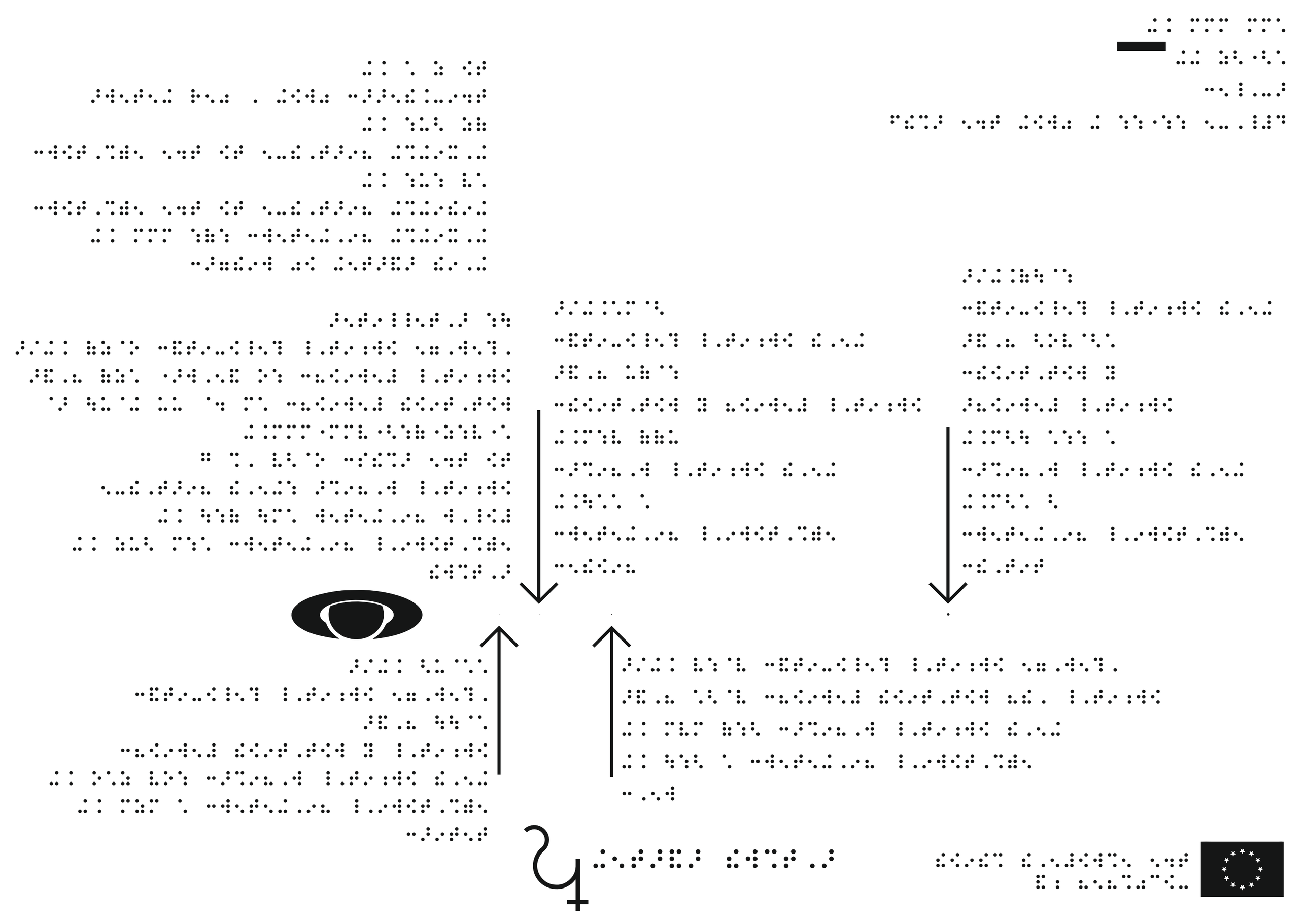
scale:

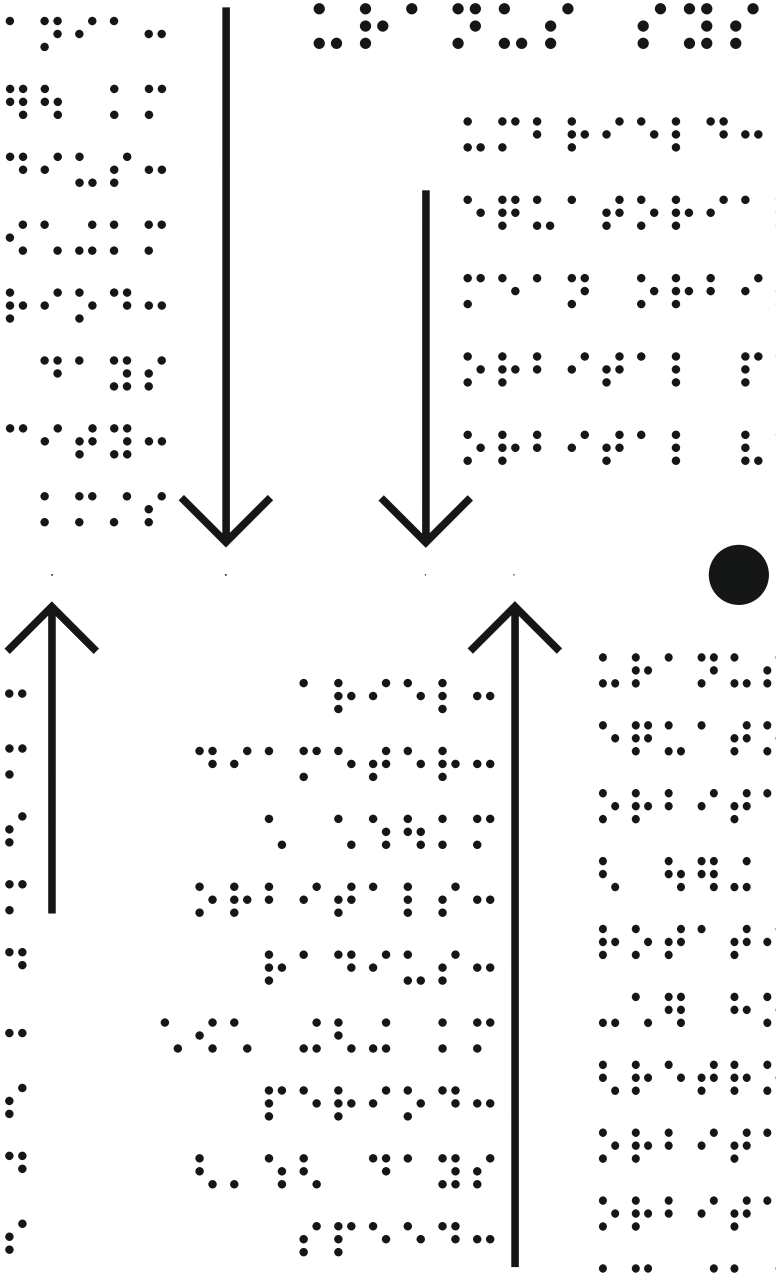
15.56 mm [redacted]

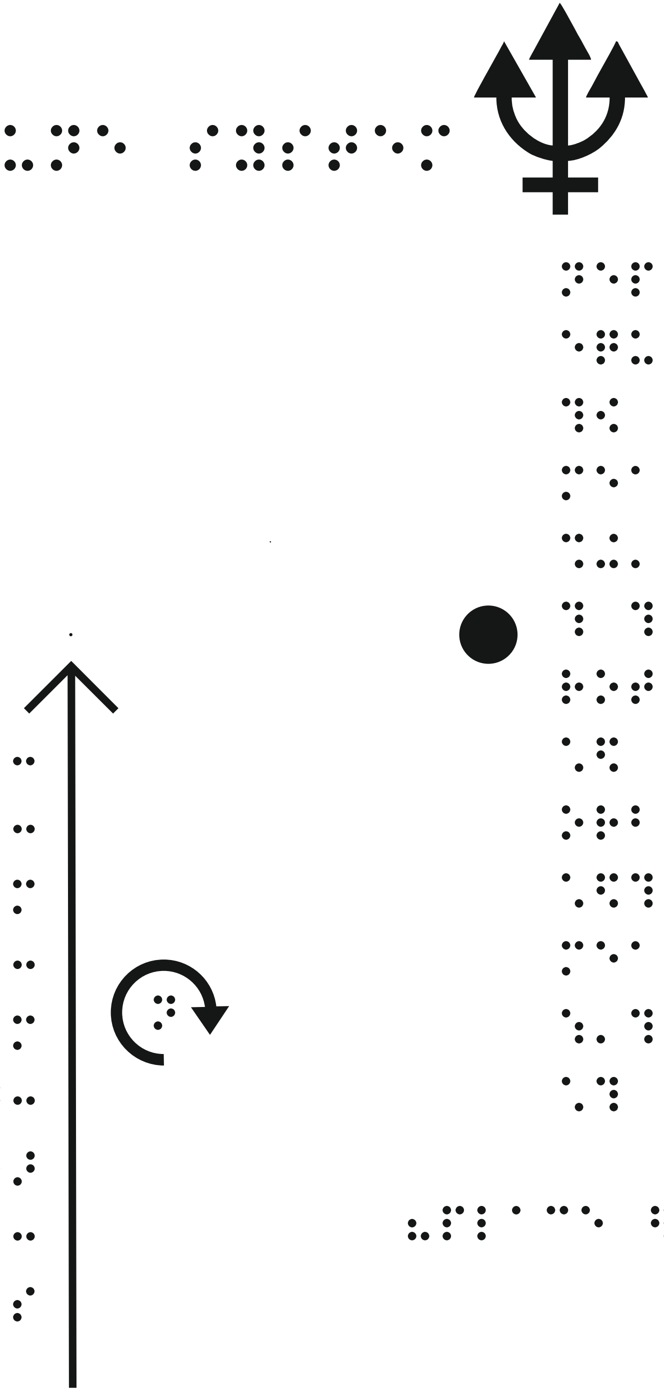
100 000 km











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