- **Concept of rounding, scientific notation, logarithm and ani-logarithm, natural and log scale**
- **Thematic map, mapping methods of thematic map**

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Concept of rounding

- It is to reduce the digits in a number while trying to keep its value almost same
- Rounding off numbers is a mathematical technique of adjusting the number’s digits to make the number easier to use during calculations.
- Numbers are rounded off to a particular degree of accuracy to make calculations simpler and the results easier to understand.

Types of rounding off

- Rounding to whole number/nearest unit
  - Example: 15.3 ➡ 15, 15.5 ➡ 16
- Rounding to decimal places
  - Rounding to 1 dp / nearest tenth
    - 274.55 ➡ 274.6, 274.95 ➡ 275.0
  - Rounding to 2 dp/ nearest hundredth
    - 5.99735 ➡ 6.00, 3.245 ➡ 3.24
  - Rounding to nearest thousand
    - 289,523 ➡ 290 thousand
  - Rounding to nearest million
    - 8500000 ➡ 8 million

Scientific notation

- Scientific notation is a form of presenting very large numbers or very small numbers in a simpler form.
- Scientific notation is a way to express numbers as the product of two numbers: a coefficient and the number 10 raised to a power
- working in Scientific Notation enables us to work effectively all while avoiding careless mistakes with decimals.
- the scientific notation helps us to represent the numbers which are very huge or very tiny in a form of multiplication of single-digit numbers and 10 raised to the power of the respective exponent.
- Scientific notation is based on power of 10

Scientific Notation Rules

To determine the power or exponent of 10, we must follow the rule listed below:

- The base should be always 10
- The exponent must be a non-zero integer, that means it can be either positive or negative
- The absolute value of the coefficient is greater than or equal to 1 but it should be less than 10
- Coefficients can be positive or negative numbers including whole and decimal numbers
- The mantissa carries the rest of the significant digits of the number

Positive and Negative Exponent

- When the scientific notation of any large numbers is expressed, then we use positive exponents for base 10. For example:
  $20000 = 2 \times 10^4$, where 4 is the positive exponent.
- When the scientific notation of any small numbers is expressed, then we use negative exponents for base 10. For example:
  $0.0002 = 2 \times 10^{-4}$, where -4 is the negative exponent.
- From the above, we can say that the number greater than 1 can be written as the expression with positive exponent, whereas the numbers less than 1 with negative exponent.

- If the given number is multiples of 10 then the decimal point has to move to the left, and the power of 10 will be positive.

  Example: $6000 = 6 \times 10^3$ is in scientific notation.

- If the given number is smaller than 1, then the decimal point has to move to the right, so the power of 10 will be negative.

  Example: $0.006 = 6 \times 0.001 = 6 \times 10^{-3}$ is in scientific notation.

Scientific Notation Examples

The examples of scientific notation are:

$490000000 = 4.9\times10^8$

$1230000000 = 1.23\times10^9$

$50500000 = 5.05 \times 10^7$

$0.000000097 = 9.7 \times 10^{-8}$

$0.0000212 = 2.12 \times 10^{-5}$

Logarithm

- Logarithms were invented in the 17th century as a calculation tool by Scottish mathematician John Napier (1550 to 1617), who coined the term from the Greek words for **ratio (*logos*)** and **number (*arithmos*)**.
- Logs (or) logarithms are nothing but another way of expressing exponents.
- A logarithm is a mathematical operation that determines how many times a certain number, called the base, is multiplied by itself to reach another number.
- A logarithm is the power to which a number must be raised in order to get some other number
- For example, logarithm of 100 with the base 10 is 2, because 10 raised to the power of 2 is 100:

$\log_{10} 100 = 2$

because

$10^2 = 100$

Again, $.001=10^{-3,}$ therefore $\log_{10} .001=-3$

Mathematical Definition

- A logarithm is defined using an exponent:

$$\log_b a = x$$

The right side part of the arrow is read to be "**Logarithm of *a* to the base *b* is equal to *x***". Here, *a* and *b* are two positive real numbers. *x* is a real number. *a*, which is inside the log is called the "argument". *b*, which is at the bottom of the log is called the "base".

Argument

$$b^x = a \Leftrightarrow \log_b a = x$$

base

What Are Natural and Common Logs?

Natural Logs

- Natural logs are nothing but logs with base ***e***.
- That is, a natural log means $\mathbf{log_e}$.
- But it is not usually represented as $\mathbf{log_e}$. Instead, it is represented as **ln**.
- Natural Logarithms have their base as **2.7183**

$$\mathbf{log_e = ln}$$

Common Logs

- Common logs are nothing but logs with base 10
- That is, a common log means $\mathbf{log_{10}}$
- But usually, writing **log** is sufficient instead of writing $\mathbf{log_{10}}$

$$\mathbf{log_{10} = log}$$

How to find logarithm

- The logarithm of any number consists of an integral part called ***characteristic*** and a decimal part called ***mantissa.***
- The ***characteristic*** of any number greater than 1 is **positive** and is equal to the number of digits before the decimal point minus one.
- The ***characteristic*** of a number less than 1 is **negative** and is equal to the number of consecutive zeros immediately following the decimal point plus one.

e.g., $\log_{10} 69=1.8388$

Number	**Characteristic**
176	2
69.58	1
3.47715	0
0.745	$\bar{1}$ (i.e., -1)
0.0745	$\bar{2}$

- The mantissa of any number is obtained from log-tables
- Mantissa is independent of the position of decimal point in the number
- The mantissa of 235.9 is the same as that of 2359 or of 0.2359 or even of 0.02358

LOGARITHMS, BASE 10 $\log_{10}x$ or $\lg x$

x	0	1	2	3	4	5	6	7	8	9	ADD 1	ADD 2	ADD 3	ADD 4	ADD 5	ADD 6	ADD 7	ADD 8	ADD 9
10	.0000	0043	0086	0128	0170						4	8	13	17	21	25	29	34	38
						0212	0253	0294	0334	0374	4	8	12	16	20	24	28	32	36
11	.0414	0453	0492	0531	0569						4	8	12	16	19	23	27	31	35
						0607	0645	0682	0719	0755	4	7	11	15	19	22	26	30	33
12	.0792	0828	0864	0899	0934						4	7	11	14	18	21	25	28	32
						0969	1004	1038	1072	1106	3	7	10	14	17	20	24	27	31
13	.1139	1173	1206	1239	1271						3	7	10	13	16	20	23	26	30
						1303	1335	1367	1399	1430	3	6	10	13	16	19	22	26	29
14	.1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	.1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	.2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	10	13	16	18	21	23
17	.2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	.2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	10	12	14	17	19	22
19	.2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	6	9	11	13	15	18	20
20	.3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	.3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	.3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	11	13	15	17
23	.3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	5	7	9	11	13	14	16
24	.3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	13	14	16
25	.3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	.4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	6	8	10	11	13	14
27	.4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	10	11	13	14
28	.4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	.4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	.4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	8	10	11	13
31	.4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	13
32	.5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	10	12
33	.5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	.5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	12
35	.5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	8	10	11
36	.5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	.5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	4	5	6	7	8	10	11
38	.5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	4	6	7	8	9	10
39	.5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	6	7	8	9	10
40	.6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	7	8	9	10
41	.6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	.6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	.6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	.6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	.6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	.6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	5	6	7	8
47	.6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	.6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	.6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8

Rules or properties of logarithm

- **Product Rule**: The logarithm of the product of two or more numbers is the sum of their logarithms

$$\log (a \times b) = \log a + \log b$$

$$\log (100 \times 10) = \log 100 + \log 10$$

- **Quotient Rule:** Logarithm of a quotient or ratio of two numbers is equal to the difference between the logarithms of the individual numbers

$$\log (a/b) = \log a + \log b$$

$$\log (100/10) = \log 100 + \log 10$$

- **Power Rule:** Logarithm of any number raised to certain power is equal to the product of the product of the power and the logarithm of the number

$$\log (a^b) = b(\log a)$$

$$\log (100^{10}) = 10(\log 100)$$

- **Change of Base Rule:** The base of a logarithm can be changed using this property.

$$\log_b a = \log_c a / \log_c b$$

$$\text{Or, } \log_b a \times \log_c b = \log_c a$$

Anti-logarithm

- The anti-logarithm of a number is the inverse process of finding the logarithms of the same number.
- If x is the logarithm of a number y with a given base b, then y is the anti-logarithm of (antilog) of x to the base b.

If $\log_b y = x$, then $y = \text{antilog } x$

Log 100 = 2

Then, antilog 2= 100

- The process of reading antilog table is exactly similar to that of log table.
- Example,

antilog 2.2425 = 174.8

COMMON ANTILOGARITHM TABLE

	0	1	2	3	4	5	6	7	8	9	Mean difference								
											1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4

Logarithmic or log scale

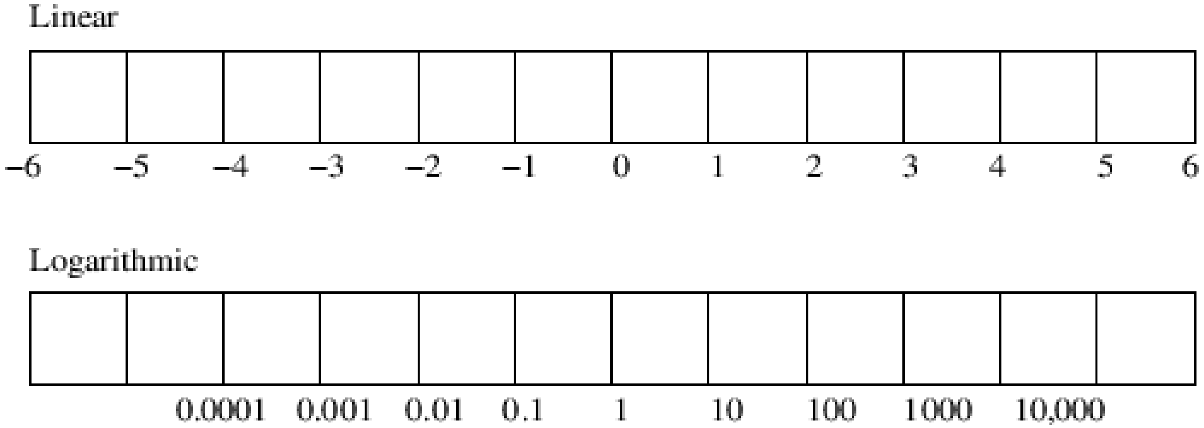
- way of displaying numerical data over a very wide range of values in a compact way
- typically the largest numbers in the data are hundreds or even thousands of times larger than the smallest numbers.
- Such a scale is **nonlinear**: the numbers 10 and 20, and 60 and 70, are not the same distance apart on a log scale.

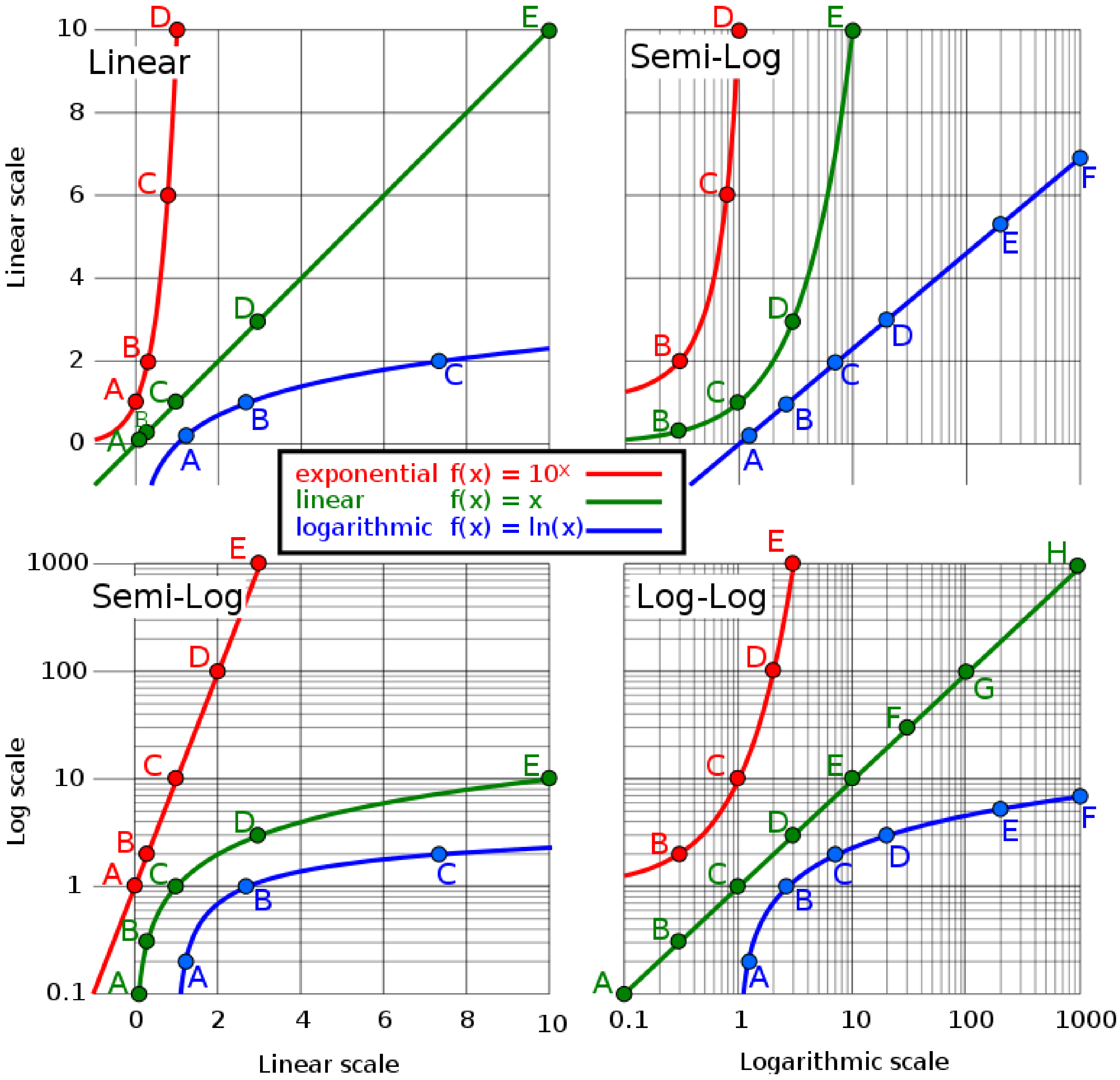
Uses of logarithmic scale

- Richter magnitude scale and moment magnitude scale (MMS) for strength of earthquakes and movement in the Earth
- Sound level, with units decibel
- Neper for amplitude, field and power quantities
- Frequency level, with units cent, minor second, major second, and octave for the relative pitch of notes in music
- Logit for odds in statistics
- Palermo Technical Impact Hazard Scale
- Logarithmic timeline
- Counting f-stops for ratios of photographic exposure
- The rule of 'nines' used for rating low probabilities
- Entropy in thermodynamics
- Information in information theory
- Particle size distribution curves of soil
- pH for acidity

Linear vs. logarithmic scales.

- On a linear scale, a change between two values is perceived on the basis of the difference between the values:
- e.g., a change from 1 to 2 would be perceived as the same increase as from 4 to 5.
- On a logarithmic scale, a change between two values is perceived on the basis of the ratio of the two values:
- e.g., a change from 1 to 2 would be perceived as the same increase as a change from 4 to 8.





Linear
Semi-Log
Semi-Log
Log-Log
exponential f(x) = 10^x
linear f(x) = x
logarithmic f(x) = ln(x)
Linear scale
Log scale
Linear scale
Logarithmic scale

Thematic maps

- A thematic map shows the spatial distribution of one or more specific data themes for selected geographic areas.
- This usually involves the use of map symbols to visualize selected properties of geographic features that are not naturally visible, such as temperature, language, or population
- The map may be qualitative in nature (e.g., predominant farm types) or quantitative (e.g., percentage population change).

Mapping methods

- Cartographers use many methods to create thematic maps.
- These are often referred to as different types of thematic maps,
- but it is more proper to call them types of thematic map layers or thematic mapping techniques, as they can be combined with each other (forming a bivariate or multivariate map) and with one or more reference map layers in a single map.
  - Choropleth
  - Proportional or Graduated Symbol Map
  - Isoline and isopleth maps
  - Chorochromatic or area-class
  - Dot
  - Sphere
  - Flow