Induction

Rules of Philosophizing

1st. More causes of Natural things are not to be admitted than are true and sufficient to explain their Appearances.

2. Effects of the same Kind are to be ascribed to the same causes.

3. The Qualities of bodies which cannot be varied and which are found in all bodies on which experiment can be made are to be considered as qualities of all bodies whatsoever.

4. In Experimental Philosophy Propositions collected from the Phenomena by induction are to be deemed notwithstanding contrary Hypothesis

either accurately true or nearly so
very
unless other Phenomena occur by which
they may be rendered either more ac-
curate or liable to exception
~~Examples~~ Illustration of these Rules

Matter

Definition — Extension, Divisibility
Solidity attraction Repulsion —
— Extension — Three Dimensions
— Divisibility — or mensuration
Remarks on the Mathematical
Demonstrations of this property
of matter
Actual Divisibility carried to —
great lengths by art as well as
Nature — Examples —

1 Light
2 Microscopic objects —
3 odorous substances
5 Metallic Arts —
4 Chemical Solutions —

Solidity ≠ the Distinguishing property
by of matter — Difference between
Physical and Mathematical Solidity
— Impenetrability — Apparent pene-
trability of bodies — Particles of matter
not in contact, ≠ proved from Elasticity
Compressibility, contraction by Cold and
by Chemical union — Therefore in
the same bulk there may be different
quantities of matter — Constituent par-
ticles suppose the same in all bodies
Density — Let M be the quantity of
matter B the bulk and D the Density

Then $M = B$
$M = D$
Necessarily $M = BD$
$B = \frac{M}{D}$
$D = \frac{M}{B}$

Weight is an annual measure of the quantity
of matter — suppose the smallest particles
of the same weight and bulk — uncertain

4

Attraction

Cohesion - Acts most powerfully when the bodies are in apparent contact and decreases rapidly by a law not yet discovered.

Phenomena

1 Bodies floating on water attract each other.

2 Water rises on the sides of the containing vessel

3. Glass plates held contiguous attract the water in which they are immersed, and cause it to rise between them above the level of the external water

4. Capillary tubes cause the water to be raised inversely proportional to their diameter

5. Surfaces of hard bodies brought into apparent contact, strongly cohere —

6

Attraction of Gravitation

Gravitation — A body unsupported descends towards the Earth — in a line perpendicular to the surface or centre of the Earth — The same on all sides of the Globe — Extends to the greatest heights we can reach without any sensible diminution — attraction of Mountains — Attraction of Gravitation greatest on the surface, and decreases in the inverse proportion of the square of the square of the distance upwards and the ~~inverse proportion~~ of the distance downwards from the Centre —

Gravity diminished at the Equator — Decreases towards the Poles — the Co-sine of the Lat — Earth supposed a Globe —

— All bodies gravitate — apparent exceptions

~~Motion~~ Repulsion

Phenomena

Water rises above the level of a dry Glass

Oil and Water will not unite

Dry Bodies when pounded will not unite

Flies walk on water without touching it —

A drop of mercury on paper and iron is round on all other metals flat. ——

Motion

Is motion is supposed to be an
attribute of Space and Time —
Space is Extension without
Solidity — Three Dimensions
The subject of Geometrical Investi-
gation — Three Dimensions
Divisible in infinitum —
Absolute and Relative — Vacuum
Time — Succession of Events — One
one Dimension — Divisible in in-
finitum — Absolute & Relative —
Measures of Time and Space —

Laws of Motion

1. Every body perseveres in a state of rest or of uniform rectilineal motion unless affected by some external force — Inertia

2. Every change of motion is proportional to and in the direction of the force impressed

3. Action and reaction are equal and in opposite directions —

Motion Absolute and Relative
Path ~~of~~ three varieties ~~Position~~ Direction Form and Magnitude — Rectilinear Curvilinear ~~motion~~ Uniform, Accelerated, Retarded ~~motion~~ Velocity —

Momentum —

Let V be the Velocity T the time S the Space ~~and~~ Rectilinear Motion in Uniform motion

1. $S \doteq T$
2. $S \doteq V$
3. $V \doteq \frac{S}{T}$
4. $T \doteq \frac{1}{V}$

Therefore $S \doteq TV$

$T \doteq \frac{S}{V}$

$V \doteq \frac{S}{T}$

Let Q = Momentum M — the quantity of matter and V the Velocity Then in Uniform Rectilinear motion

$Q \doteq M$

$Q \doteq V$

3 $Q \doteq MV$

$M \doteq \frac{Q}{V}$

$V \doteq \frac{Q}{M}$

The instantaneous action of the moving cause is sufficient to produce continued motion — Inertia or vis insita —

Compound Motion

A body acted on by two forces represented in quantity and direction by the sides of a parallelogram, will describe the Diagonal in the same time that it would describe the sides by the ~~two motions~~ separate action of those forces. — Composition and resolution of forces — Constituent — resultant. — Equilibrium —

Mechanic Powers —

Lever — Three Kinds

1. When the fulcrum is between the power and the weight
2. When the weight is between the fulcrum and the power
3. When the power is between the weight and the fulcrum

Equilibrium is all when the power and weight are inversely proportional to their Distance from the fulcrum. — Balance —

Wheel and Axle —

Q. Equilibrium when the power is to the weight as the Diameter of the axis to the Diameter of the Wheel —

~~Balance~~

~~Pulley~~ — Pulley gives no mechanical advantage —

2

14

In a ~~Lever~~ moveable Pulley there is an Equilibrium when the power is to the weight as 1 to the number of ropes by which the System is block is suspended — Various other combinations —

4th — Inclined Plane

Equilibrium when the power is to the weight as the height of the plane to its length — Three varieties —

5 — Wedge and Combinations

Different opinions respecting this mechanic power — Equilibrium has been ascertained by Theory, and not proved by experiment — Reasons assigned —

6 — Screw —

Equilibrium when the power is to the weight as the distance of two consecutive threads to the circumference whe

15

e power describes — Double and triple
ower — Tangent Screw

Center of Gravity

The center of Gravity is that
point round which all the parts
of a body ~~balance~~ equally ~~each other~~
when the center of Gravity is sup-
ported the body remains at rest —
Line of direction — when this falls
within the base, the body is supported
— Center of a single body — of a
system, how found —

Of motion by Gravity in perpendicular lines

Descent of a body by Gravity — in a
line perpendicular to the horizon —
Motion uniformly accelerated — Spaces
are as the squares of the times —
— The velocity at any point would,
if continued uniform, carry the body
thro' twice the space already described
— A body on or near the surface of the

10 Earth and descending bodies perpendicularly by gra
descends a space of 16.1 feet in
second — Hence $16.1 \times T^2 =$ spac

Of Motion by Gravity
on inclined Planes

— Uniformly accelerated — when
perpendicularly by the same as from the sa
heights — Times on Different Pla
are as their Lengths — Velocities
the square roots of the Lengths
Times are on inclined Planes
to the perpendicular as the Lengths
to the Heights — Descent thro
the Diameter and all the Chord
of a circle in the same time

Pendulum —

Vibration — Point of Suspension —
Centre of Oscillation or Percussion
Cycloid —

Pendulums of the same length
vibrate in the same time

The time of Vibration in the
Chords of a Circle is equal to
the time of Descent thro' a time
the length of the Pendulum

The time of a vibration in
any arc of a Cycloid or
a very small arc of a Circle,
is to the time of perpendicular
Descent thro' half the length
of the pendulum as the circum-
ference of a Circle to the Diamet.

The vibrations in small
unequal arcs of a Circle are nearly
equal

5. Times of vibration in pendulums of different Lengths are as the Square roots of the Lengths

6. A Cylindric rod will vibrate the same time as a pendulum of $\frac{2}{3}$ its Length — x Action of G.

— Application of the Pendulum Clock works — Great and Small arches — Effect of heat — Compens. Pendulum —

Of Motion by Collision —

Non-elastic bodies —

1. Equal bodies with equal and contrary motions, on collision rest —

A body striking an equal body at rest, after collision they both rise to half the height of the striking body

2. The Quantity of motion after the Stroke is the same as before the Stroke —

4. When the bodies strike in opposite directions, the Diff. of their motions before the Stroke will be the sum of their motions after it

5. In all com— Motion lost by the one is communicated to the other body —

Elastic bodies

6. Equal elastic bodies with equal and contrary motion: after collision both rise to the height from which they descended

7. A body striking an equal body at rest, on collision the striking body remains at rest and the other rises to the height from which the former descended — Here the striking body loses its whole motion and the other acquires as much

8. If two or more Elastic bodies be struck with one, the ball which is furthest from the striking ball will fly off with the velocity of the striking ball, leaving it and all the others at rest.

Projectile Motion

Curve of a projectile a parabola if impetus = Random – line of direction

Times of Ascent and Descent the same

First and last velocities the same

3. Vertex divides the curve into two equal and similar parts

4. Greatest Random or Range at an elevation of 45°.

5. If the elevations be equally distant from 45 the ranges will be equal

6. The Greatest range is double the impetus

7. With the same impetus, the ranges are as the sines of

Double the angles of elevation

8. The square of the time of flight in seconds multiplied by 16 gives the greatest random

Observations

Resistance of the air to shot & shells very great Military projectiles Initial velocity - how ascertained - Ballistic Pendulum —

Force of Gun Powder —

1. Initial velocity as the square roots of the charges
2. Ranges as the square roots of the velocities — with the same velocities of different shot are inversely as the square root of their weights
3. With the windage = 1/20 Calibre from 1/3 to 1/4 of the force of the powder is lost. —
5. No change in the velocity by varying the weight of the gun, by using a ball of different degree of runniness or from the charge

26

12 Charge in different places —

9 Gun powder fine almost in
vacuity —

10 Use of Chamber

11 ~~Rifled guns~~ — Deflection
of the ball — cause

12 Rifled Barrels —

18 Recoil — not affected by
present degree of ramming —

19 Whether the recoil be owing
to the rushing of the air in
the emptied gun —

27

+ ~~Centripetal Attraction~~
~~Central Forces~~ —

Centripetal — Centrifugal Projectile
Force

Centripetal Force as the quantity
of matter

— & the Distance directly and
reciprocally —

C. F. would generate, in a
given time, a velocity equal to that
of a body passing through twice
the radius

Velocity in different points of
the orbit reciprocally as Tangents
& as Perpendiculars to or the
Tangents through those points —

Areas are proportional to the
times

6. Squares of the Velocities proportional to the Cubes of the Distances.

Compound Engines

Master to explain the Power and
so every Engine the Power and
weight will be in Equilibrio when
they are reciprocally as their velo-
cities, or Spaces moved through —
+ Then a great number of Compound
Engines shewn and examined —
— Wheel Carriages — a Wheel
Mechanick [illegible] a Wheel compound
great [illegible] small — Wheels compound
— Docking — Hoop Tyes — Bent rim —
Block — Rule for setting the wheels
Great and small Wheels compared
Mode of yoking — Waggons —
Single horse carts —

Strength of Timber

1st to crush it lengthwise
2. to tear it endwise
3 to break it crosswise

1st insurmountable by Art —
2 very great – determined by Exper[illegible]
Tenacity of several substances – ~~Experiments~~

a wire 1/10 of an inch in D[illegible]

of Gold supported a weight of	500
Silver	370
Copper	30[illegible]
Iron	45[illegible]
Tin	4[illegible]
Lead	[illegible]
Zinck	1[illegible]

A rod of fir one inch in ~~circum~~ lengthwise supported — 2[illegible]
Ditto 2 Inches in Diam. 7[illegible]
A rod of iron 1 inch in circumf. 3[illegible]

Hempen Rope of one inch circ. 1000
[illegible] to do

3. Main — Beams crosswise

~~Beam~~ Absolute Strength determined by experiment —
A piece of Oak one inch square and 36 Inch. just supported a weight hung to its middle of — lb 330

Relative Strength

Oak	12
Yew	11
Ash	10
Elm	9
Walnut	8
Fir, Alder, Plane	7
Beech, Birch, Willow	6

Strength varies in different trees and even different parts of the same tree —

Beams & joists are to each oth
as the sections made by the
and divided by the length —
Hence the advantage of placing
on their smaller sides —
Oblique pressure is to horizontal
as the Co. sine of the angle of Elev
to the Radius. —— Roofs. — Flo
Bridges — Centers

Hydrostatics

Solids — Fluids — Laws of Fluidity
Compressible — incompressible Fluids
Mechanical properties of Water and
other incompressible Fluids

A Fluid has weight — gravitates in
itself and in every other Fluid —
Presses equally in every direction
The pressure is in proportion the
bottom and perpendicular height whether
any regard to the figure of the Vessel
or quantity of the Fluid — Hydrostatic
Paradox
Fluids rise to the same level — surface
convex — Theory and practice of Levelling

Resistance of Fluids

In proportion to the density of the
Fluid —

6. As the square of the Diameter
7. As the square of the Velocity
8. Rules of Resistances
Motion of Fluids
9. Quantity discharged is in proportion to the square of the Diameter of the orifice and square root of the Pressure last
the Surface
10 Spouts to raise the height of the reservoir — Water works
11. Conical Aqueducts — Clepsydræ and other contrivances for measuring time — Method of levelling in England used for this purpose
12. Springs and Rivers

Specific Gravity of Bodies
Bulk — Quantity of matter — Density
Rare —
1 Body specifically heavier than a fluid sinks, if lighter it swims of the same Sp: G^y with the fluid in any where in the fluid
2. The weight of a body in water is less than in air —
3. A Body weighed in water loses as much of its weight as is equal to the weight of a quantity of water of the same bulk with the body
4. The weight lost is proportional to the surface of the body and specific gravity of the fluid
5. The water displaced by a body is equal in weight to the body

6. A body is ascends and descends in a fluid with velocities proportional to the specific Gravities

7. Hydrostatic balance – its construction & use –

8. Hydrometers of different construction –

9. Table of Specific Gravities –

10. ~~Miscellaneous Observations~~ Hydraulic Engines

Pneumatics

Compressible fluids – ~~Air~~

Mechanical properties of air

1. Has weight

2. Presses with a force proportional to its perpendicular height – pressure equal to 15 lbs Avoirdupois on a square inch

3. Air is Elastic –

4. Elasticity proportional to the compressing force

5. Spaces inversely proportional to the pressure –

6 Height of the atmosphere

7 Barometer – Mensuration of heights by the Barometer –

8. If altitudes be taken in arith. progression the ~~[illegible]~~ density of the atmosphere will be in geometric progression

9. Air is contained in the pores of bodies —
of Sounds

10. Air the medium of sound — Simple pulses — Compound Sounds — Velocity — Reflected sound Echos — Augmentation of sounds

11. Musical sounds — Vibration of strings — Scale — Melody Harmony — Musical Instruments

Magnetism

Properties of the Magnet

1. Attracts iron

2. Attraction greatest in appearance contact, and diminishes by a law not yet yet ascertained

3. Arranges it self in a particular position with respect to the axis of the Earth. — Poles — Variation

4. Similar poles repel — dissimilar poles attract each other — Curves —

5. Magnetism not destroyed by communicate, nor interrupted by the interposition of any body between the Magnet and the iron

6. Magnets made various ways — Needles touched — Mariners Compass

40

7. Theorie of Magnetism

* Every pole of the magnet makes a contrary pole in the Needle

x Induction or Dep —