

8-7



0356

Handwritten text on a document page, mostly illegible due to fading and low contrast. The text appears to be organized into several lines or paragraphs, but the specific words and numbers are difficult to discern. Some faint characters and numbers are visible, such as '1000' and '1000' in the lower half of the page.

0357

Thursday Decem. 10. 1674.

At a Meeting of the Council  
of the Royal Society.

**W** Hereas it was desired by  
the Royal Society, that  
a Discourse made before them by Sir  
William Petty Knight, at their  
Meeting the 26. of November  
last, might be Printed: It is this  
day Ordered by the Council of the  
said Society, That the said Dis-  
course be Printed by the Printer of  
the Royal Society.

BROUNCKER, P. R. S.

THE  
DISCOURSE  
Made before the  
Royal Society

The 26. of November 1674.

Concerning the Use of

**Duplicate Proportion**

In sundry Important Particulars:

Together with a

*New Hypothesis of Springing  
or Elastique Motions.*

BY

Sir WILLIAM PETTY, Kt.  
Fellow of the said Society.

*Pondere, Mensura, & Numero Deus omnia fecit:  
Mensuram & Pondus Numeres, Numero omnia  
fecit.*


L O N D O N:

Printed for John Martyn, Printer to the  
Royal Society, at the Bell in  
St. Pauls Churchyard, 1674.

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To his Grace,  
**WILLIAM,**  
LORD DUKE OF  
*NEWCASTLE.*

*May it please your Grace,*

 Am comman-  
ded by the  
*Royal Society*  
to Print the Dis-  
course, which I made

A 3 be-

### The Epistle

before them, upon the last Meeting-day of *their* last year, and next before that of their *Anniversary Election*: Because, as Drapers cut Patterns of their whole Cloth out of an End, not because the End is better than the rest, but because it may be best spared; so (I suppose) the

### Dedictory.

the *Society* are content, that this Exercise pass for a Sample, *pro tanto*, of what they are doing; for that the same may be conceived to consist of three parts, *viz.* The *first* being an Endeavour to explain the Intricate Notions, or *Philosophia Prima* of Place, Time, Moti-

A 4 on<sup>e</sup>

The Epistle

on, Elasticity, &c. in a way which the meanest Member of adult Mankind is capable of understanding : The *second* being, to excite the World to the study of a little Mathematicks, by shewing the use of *Duplicate Proportions* in some of the most weighty of Humane

Dedictory.

mane affairs, which Notion a Child of 12 years old may learn in an hour : And the *last* being, without Chymical Speculations, to consider such points and properties, even in *Atoms* (such, whereof perhaps a Million do not make up one visible *Corpusculum,*) as may

A 5 give

The Epistle

give an intelligible Account of the Nexures, Mixtures, and Mobilities of all the parts of the Universe.

In like manner, 'tis the Profession of the Society, to make Mysterious things plain; to explode and diffuse all insignificant and puzzling words;  
to

Dedatory.

to improve and apply little small threds of Mathematicks to vast uses; and yet not to neglect the finest Consideration, even of *Atoms*, where the same is necessary. The which purposes of theirs, I venture to say, do as much differ (both as to *difficulty* and *dignity*)  
from

The Epistle

from what is commonly called *Wit* (and which takes with far the greater part of Mankind,) as the skill of Drawing and Painting a Cloud or Periwig doth from that of Designing or Painting many complicated Figures of Men and Beasts in some one Table, where-

Dedictory.

wherein each is perfectly to express some particular passion, and all standing together to contain the true and entire Spirit of the Story represented: For, in the *latter*, precise exactness is indispensable, whereas in the *former*, not onely liberty always, but even extravagancy

The Epistle

cy sometimes is not  
onely tolerable, but  
laudable. And when  
I have said this; I  
withal say, that there  
is one Glory of the  
*Sun*, another of the  
*Moon*, and another  
of the *Stars*, which  
may all consist toge-  
ther, without de-  
stroying or malig-  
ning each other. And  
all

Dedicatory.

all these several Glo-  
ries shine steddily in  
your Graces Firma-  
ment.

Being, I say, ap-  
pointed to publish  
this Exercise, I have  
presumed to dedicate  
it to your Grace.  
First, because the *So-  
ciety* have been plea-  
sed to order it to be  
published; ( I dare  
not



The Epistle

not say, as approving  
it, but as committing  
it to Examination.)  
Secondly, because  
your Grace doth not  
onely love the search  
of Truth, but did en-  
courage Me 30 years  
ago as to Enquiries of  
this kind. For about  
that time, in *Paris*,  
*Mersennus*, *Gassendy*,  
*Mr. Hobs*, Monsieur  
Des

Dedicatory.

*Des Cartes*, Monsieur  
*Roberval*, Monsieur  
*Mydorge*, and other  
famous men, all fre-  
quenting, and caref-  
fed by, your Grace  
and your memorable  
Brother, Sir *Charles*  
*Cavendish*, did coun-  
tenance and influence  
my Studies, as well  
by their Conversati-  
on as their Publick  
Le-

**The Epistle**

Lectures and Writings: Much of which honours and helps I ow unto your Grace, and have a fresh remembrance of them. Thirdly, because my Lord *Ogle* being now about to carve a significant Figure upon my Lord his Son, by his careful Education of him, I thought it a service

**Dedictory.**

service to his Lordship, as well as an Expression of my Thanks for his former acceptance of my Endeavours, to call upon him, not onely to instruct my Lord his Son in some Mathematicsk, but also to store and stock him with variety of *Matter, Data* and *Phænomena,*

The Epistle

*mena*, whereupon to  
exercise the same;  
since *Lines & Num-*  
*bers*, without *those*,  
are but like Lute-  
strings without a  
Lute or a Hand. For,  
my Lord, there is a  
*Political Arithmetic*,  
and a *Geometrical Ju-*  
*stice* to be yet further  
cultivated in the  
World; the Errors  
and

Dedictory.

and Defects where-  
of, neither Wit, Rhe-  
toric, nor Interest can  
more than palliate,  
never cure. For, Fal-  
sity, Disproportion,  
and Inconsistence can-  
not be rectified by a-  
ny sermocinations,  
though made all of  
figurate and measured  
periods, pronounced  
in Tune and Ca-  
dence,

The Epistle

dence, through the most advantageous organs; much less by Grandisonous or Euphonical Nonsense, farded with formality; no more than vicious Wines can be remedied with Brandy and Honey, or ill Cookery with enormous proportions of Spice and Sugar:

*Nam*

Dedictory.

*Nam Res nolunt male administrari.*

These are the Reasons, why I have put your Graces Name to this Treatise; though there is a contrary reason, why it should have wholly *shun'd* your Graces sight and knowledg: which is, That your Grace might not perceive how

The Epistle

how little progress I have made in thirty years time upon those Studies. However I hope your Grace will take what I have done for an Argument of my patience and perseverance in these pleasant, though profitless, Employments, and see, that no heterogeneous Cares and Troubles

Dedictory.

Troubles have or can quench my affections to Philosophy, as no distances of Time or Place have made Me less than formerly,

Your GRACES

*Most humble, most faithful, and most obedient Servant,*

Wlt. Decemb.  
1674.

WILLIAM PETTY.

( 2 )

To

*To the Right Honourable*

**WILLIAM**  
 Lord Viscount *Brouncker*,  
**PRESIDENT**  
 OF THE  
**Royal Society.**

My Lord,



*H E Observati-*  
*ons on the Bills*  
*of Mortality*  
*were distinctly*  
*Dedicated to a Peer of this*  
*Realm, and also to the Presi-*  
*dent of the Royal Society,*  
 (a 2) *and*

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The Epistle

and both with good acceptance: Wherefore I have also (like the Author of those Observations) Dedicated this Discourse to his Grace the Duke of Newcastle, for the reasons in the foregoing Epistle mentioned; and I now again Dedicate the same to your Lordship. First, In Gratitude for the several assistances I had from your Lordship towards the Experiments mentioned in this Discourse. Secondly, Because your Lordship is an Eminent Judge

in

Dedicatory.

in those Matters, a Person whose Animadversions I shall take for Kindnesses; and who is able to excuse the Errors, and defend the Truths I have delivered. Lastly, For that near half the whole Discourse relates to Shipping, Artillery, Fortresses, Seabanks, &c. which all concern his Majesties Service, and part whereof are happily entrusted by him to your Lordships Care; I thought I might express My affection to those his Majesties Con-

(a 3) cernments

The Epistle, &c.

cernments even by offering  
this my Mite unto them.  
Upon the whole Matter, I  
have layd hold on this Occa-  
sion, to Publish my desire of  
being esteemed,

My LORD,

Your Lordships most  
humble and faith-  
ful Servant

Ult. Decemb.  
1674.

WILLIAM PETTY.

ERRATA.

Page 6.l.5. r. Proportion. p.44.l.1. r. be for  
being. p. 49. l.6. r. &c. be. p. 49. l. 13.  
r. moreover for viz. ibid.l.14. r. Mice, or rather  
some smat Animals (whose correspondent parts  
are but  $\frac{1}{2}$  in length of the Horses.) ibid.  
l. ult. r.  $\frac{1}{44}$  for  $\frac{1}{44}$  p.87. l.10. r. Numerus  
for numerous. ib. l. 11. r. of for or. p. 88. l.8.  
r. whereof for thereof.

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[ 1 ]

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A  
DISCOURSE  
TO THE  
Royal Society.

**I** Orasmuch as this  
*Society* has been  
censured (though  
without much cause) for  
spending too much time in  
matters not directly tend-  
ing to profit and palpable  
Advantages (as the Weigh-  
ing of Air and the like)

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[ 2 ]

I have therefore, to streighten this crooked stick, bent it and my present Discourse the quite contrary way, *viz.* to the *Sails* and *Shapes of Ships*; to *Carpentry* and *Carriages*; to *Mills*, *Mill-dams*, *Bulwarks*; to the *Labour of Horses*, and to several other particulars: The which are not only gross enough of themselves, but are also as grossly handled in this Exercise, to prevent the further imputation of needless Nicerity,

[ 3 ]

ty, and to leave room for your own further thoughts upon the same.

And forasmuch as We have been also complained of for producing nothing New, I have together with my Instances and Applications, above and hereafter mentioned, presented you as an Appendix, to what is said of *Springs* and other *Elastique bodies*, with a new Theory (as I think) of *Elasticity* it self, and that mechanically explicated in

B 2 or.

[4]

order to make a breach on this hard Rock in Philosophy, and to chip off a little of that Block which has long lain thwart Us, in the way of Our Enquiries. Upon the whole matter I have followed the Example of *Elderly Divines*, who finding their Flocks not to mend their lives by perplexed Discourses about Predestination, Transubstantiation, &c. betake themselves at last to preach *Faith* and *Good Works*,  
*Neigh-*

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*Neighbourly Love*, and *Charity*, or *Doing as we would be done unto*, and the like. For I have in this Exercise declined all Speculations not tending to practice, and ventured at few new Hypotheses, but that of *Elasticity*; rather calling upon you to review your own former Observations, and to apply your *Mathematicks* to *Matter*, so as both may be improved to the profitable purposes hereafter mentioned.

B 3 Where-

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Wherefore the Title and Scope of this Exercise is, *Several Instances, wherein the consideration of Duplicate & Subduplicate propoortion, or wherein the consideration of Sides and their Squares is of use in humane affairs.* And the *Instances* which I have pitcht upon for this day are these following, viz.

1. In the *Drawing* or *Driving powers*, which force *Ships* or other bodies through the water, with reference to the respective  
Velo-

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*Velocities* caused thereby.

2. In the *shapes* or *sharpness* of bodies, cutting or dividing the water, through which they are *driven* or *drawn*, and in the different *Velocities* arising from thence, where the *Bodies* and *Forces* are equal.

3. In the *Strength* of *Timbers* or other homogeneous materials applied to *Buildings*, to *Carts*, or any other *Machinaments* intended for strength: And how by a *Model* to judg

B 4 the

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the sufficiency of such *Engine* as is represented by it.

4. In the effect of *Oars* upon equal and like *Vessels*, according to their *Numbers, Length, Blades,* and *Motions* with or against the *stream* of *smooth* or *uneven* waters.

5. In the *Motion* or *Travelling* of *Horses*, on their several *Paces*, and with different *Burthens* on them.

6. In the *Strength* and *Velocity* of *Mills* and their *Wheels*.

7. In

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7. In the Effects of *Gunpowder*.

8. In the Distance at which *Sounds* may be heard.

9. In the Distances at which *Odoriferous matters* may be smelt.

10. In the Distance at which the *Objects of Sight* may be seen.

11. In the time of the Returns made by *vibrating Pendules*.

12. In the *Lives* of men and their *Duration*.

B 5

13.

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13. In *Musical & Sounding Bodies*, such as *Strings* and *Bells*.

14. In the *Effects* and *Motions of Fire*, and *burning Spirits*.

15. In the *Rising* and *Falling of Bodies*, but especially of *Water* in *Pumps*, *Overshot Mills*, *Leaks* in *Ships*, the *Heights of Rivers* at their head above their fall into the *Sea*.

16. In *Bellows*,

17. In the *Prices* of several *Commodities*, as *Masts*,  
*Diamonds*,

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*Diamonds*, *large Timber*,  
*Amber*, *Loadstones*, &c.

18. In *Mill-dams*, *Seabanks*, and in the *Bulwarks* or *Walls of Fortresses*.

19. In the *Compression* of *Wooll*, and other *Elastick Bodies*, and of the *Air* within diving *Vessels*, as also in the *Effects* of *Skrew-presses* upon several *Materials*.

Having thus enumerated my several *Instances*, wherein *Duplicate*, and *Subduplicate* proportion is of great importance; I might

now

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now fall down-right upon the Application of those proportions to each of the respective matters above mentioned. But because Custome hath made it almost necessary to make a *Preface* to every Discourse, my *Preface* to this one *Lecture* shall be such, as may serve me for many more; that is, an Explication of what I my self (at least) understand by *Matter, Body, Figure, Place, Motion, Quantity, Quality, Habit, Time, Proportion,*

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*Proportion, Weight, Swift-ness, Force, and Elasticity;* which I shall do without imposing or scarce recommending the same to any other. For I would be glad, when any man speaks to me in matters of importance, by words which he uses often, that he would first give me a *Dictionary* of such words, to contain what he himself meaneth by each of them. Wherefore I shall, as a *Preface*, prefix this *Dictionary*, wherein I dare

dare not define *Matter* by *Ens*, or *Substance*, because I think most men conceive *Matter* better than they do either of these two words, *Ens*, or *Substance*. Nor do I define the words, *Think*, *Consider*, or *Conceive*, by the words, *Soul*, *Spirit*, *Act*, or the like, for the same reason. But presuming you all understand, *conceive*, *imagine*, or *fancy* the words *Matter* and *Thought*, as well as any other I can use, I venture to say as follow-

followeth, and first, That

1. *Place* is the Image or Fancy of Matter, or Matter considered.
2. *Quantity*, the Fancy of Place.
3. *Ratio*, several Quantities considered together.
4. *Proportion*, several like *Rationes*.
5. *Situation*, several Places considered together.
6. *Figure* is Quantity and Situation considered together.
7. *Body*



7. *Body* is Matter and Figure considered together.

8. *Motion* is change of Place.

9. *Time*, the Image of Motion.

10. *Quality*, several Motions considered together.

11. *Habit*, the same Motions repeated.

12. *Likeness*, several Figures, or Qualities, and Proportions considered together.

13. *Swiftness*, Time and Place,

Place or Space considered together.

14. *Force* is Body and Swiftness considered together.

15. *Right* is the Image of Possession, and is to it as Place to Body.

16. *Elasticity* I shall speak of hereafter.

In the next place, I suppose all the *First Matter* of the World to be *Atoms*; that is, Matter Immutable in Magnitude and Figure.

I suppose *Corpuscles* to be as

as many Atoms joyned together, as make up a *visible* or *sensible Object*, and that all *Figure* of *Atomes* is made by their *Innate motions*. Moreover I suppose, That every Atom is like the Earths Globe or Magnet, wherein are *three Points* considerable, *viz.* two in the surface, called *Poles*, and one within the substance, called *Center*, or rather *Byas*, because in Atoms we consider neither *Magnitude* nor *Gravity*.  
 These

These Atoms also may have each of them such Motions as *Copernicus* attributes to the Earth, or more. Lastly, Motion *to* or *from* a Point makes a *streight Line*, and, *about* it, a *Circle*. But *from* the *Center* to several Points in the *Circle*, is *Angle*. We further say, that the motions of *Corpuscles* are compounded of the abovementioned motions of Atoms; and the motions of bigger and Tangible Bodies (*viz.* their qualities) are decom-  
 pounded

pounded out of the *Motions, Situation, Figure, and Magnitude* of Corpuscles; and that out of, and by, the premisses all *Phænomena* in nature must be solved. And this is all the Preface I shall trouble you with, being (as was said) the *Dictionary* wherein to find what I mean by every material word I intend to use in this ensuing Exercise, which we thus begin, *viz.*

The

The first Instance,

*Wherein Duplicate, and Subduplicate Ratio or Proportion is considerable, Is*

**I**N the *Velocities* of two equal and like *Ships*; which *Velocities*, I say, are the *square Roots* of the *Powers* which either drive or draw them; as, for example, Such two *Ships* having sails near double  
to

[ 22 ]

to each other, or as 49 to 25, the Velocity will be as 5, the square Root of 25 unto 7, the like Root of 49. Again, if the sails be near triple, or as 49 to 16, there the Velocity shall be as 7 (the Root of 49) to 4 (the Root of 16.) So as a *quadruple Sail* is requisite to *double* swiftnes, and *nonuple* to *treble*; that is, The sails must be in duplicate proportion to the swiftnes of the Ship; or this, in subduplicate to that.

Again,

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Again, let there be two Ships of Equal sails, but of unlike or unequal sharpness, suppose the head of one extremely obtuse or quite flat, and the head of the other to be an *Isoceles Triangle* added thereunto; I say, the swiftnes of these Bodies shall be as the Roots of the Perpendicular of that Triangle to the Root of half the Base, or half breadth of the same. Secondly, Or if the same Triangular head be cyphered away

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away into an Angle from bottom to top ; then, as the Root of the same Perpendicular is to the Root of the Depth or Thickness, so are the Velocities. Thirdly, If the said head be cyphered both wayes together, then the Proportion of Velocities shall be as half of one of the above mentioned Proportions added to the other whole Proportion : *Ex. gr.* Suppose the Perpendicular of the triangle-head be

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be 36, the half breadth 9, and the whole depth be 4 ; then the one Proportion shall be as 6, the Root of 36, to 3, the Root of 9 : The half of which Proportion is as 6 to 6 ; and the other Proportion is as 6, the Root of 36, to 2, the Root of 4. Now add the Proportions of 6 to 6, to that of 6 to 2, the sum will be, as 36 to 12, or as 3 to 1.

Fifthly, Suppose two Parallelepipedons of unequal heads or resistances, *Ex. gr.*

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as

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as 8 to 5, or 64 to 40: And suppose the Sail on the bigger, to that on the lesser, to be as 9 to 4, or 72 to 32; then the Velocity of the bigger shall be to the Velocity of the lesser, as the Root of 45 is to the Root of 32. For if the Resistances be as 64 to 40; then, if the sail of the bigger to that of the less were proportionable to the Resistances, the sail of the less should be 45, whereas we suppose it but 32. Wherefore

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fore the Velocity shall be as the Root of 45, which is almost 7, to the Root of 32, which is about  $5\frac{1}{2}$ , that is, as about 14 to 11.

*Memorandum*, That wetting of Sails (by lessening the intersperst apertures between the threds of the Sail-cloth) doth make the Sail, as it were, bigger; which biggerness may be known and measured by the increase of the Ships velocity upon such wetting. For, if the Ship should

C 2      move

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move one tenth part quicker after wetting than before, we may conclude the Sails are swollen to the equivalent of about  $\frac{1}{5}$  part bigger; for 100 (whose Root is 10) exceeds 81, whose Root is 9, by about  $\frac{1}{5}$  of 100.

By these ways the different Velocities, arising from the different Trim of the same Ship, may be also computed, the best Trim being that which makes least resistance, *ceteris paribus*.  
Now

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Now, having said thus much of the Effects of Sharpness and Sails, (the two principal causes of Velocity in shipping, and unto which all others may be referred;) I shall add, That the want of these two Advantages are the chief cause, why short, bluff, undermasted Vessels sail cheaper than others.

For suppose two Ships of equal burthens, but of unlike dimensions, the main Beam of the one being  
C 3 ing

ing scarce  $\frac{1}{3}$  of the Keels length, and in the other, a full  $\frac{1}{5}$ <sup>th</sup>; I say first, that the Hull of the latter shall cost  $\frac{1}{3}$  part more than that of the former, and the advantage as to sailing shall be scarce  $\frac{1}{6}$  part. Again, suppose, the sharper could carry  $\frac{1}{2}$  as much sail more as the bluffer, whereof the advantage in sailing would be  $\frac{1}{6}$  part more, in all  $\frac{1}{3}$ . Now, where the Sails are as 2 to 3, the Masts and Yards must be as 4 to 9 in substance; and

and in value much more: And where the Masts and Yards are as 4 to 9 in weight and bulk, the Cordage and Rigging must be answerable: And where the Masts, Yards, Sails, and Rigging are great, the Wind-taught of the Ship will correspond, and will require proportionable Cables; and the weight of the Anchor must follow the size of the Cable, and the number of hands must be proportionable to all the



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premisses : So as the one Ship will cost at least double as much as the other, and will sail at double charge of Wages and Victuals, Ware and Tare, &c. Now if no trading Ship be (one time with another) above  $\frac{1}{10}$  of her whole reign under sail, or 6 days in 60, suppose the sharper and larger-sail'd Ship sail in 4 dayes what the other performs in 6; the difference will be but 2 dayes in 60, or  $\frac{1}{30}$  part of the Wages,

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ges and Victuals, and other charges; whereas the charges is supposed to be more than double. I say, this consideration is of great weight in Vessels of burden, especially such as carry gross and cheap bulky Commodities, neither liable to damage or perishing : Of which goods 7 parts of 10 of all Seacarrriage do consist. But on the other hand, where safety against Enemies, speedy dispatch upon im-  
 C 5;      portant.

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portant occasions, or pre-occupation of a Market are in the case, there sharpness and great Sails may be admitted to the greatest proportions practicable.

Having thus digressed, I mind you that we said, *Velocities are the Roots of Resistances and Extent of Sails, &c.* It may be well askt, How we know the same, since that very few Seamen or Shipwrights, either in their writing or discourses seem to understand  
or

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or own this important Position. To which I answer, that I have by many Observations, Calculations, and Comparisons, found the same to be *præter propter* true, although there be many circumstances which intermingle themselves in this Experiment, so as to disturb and confound it: As namely, The ill placing of Masts, The ill cutting and standing of Sails, The ill Trim of the Vessel, with the Cleanness or Foulness  
of

[ 36 ]

of the same; The Sails more or less worn or wet; as also taught or slack Rigging, &c. Wherefore not only to avoid these last mentioned Intricacies, but also to make these Positions Examenable by every one that desires it; I say, that the different Velocity of Bodies (of several sharpnesses, and as drawn or driven by different Powers of knocks or falling weights,) have been by my self and others much experimented  
in

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in large *Canales*, or *Troughs* of water, fitted with a convenient Apparatus for that purpose, and by no man more, nor more judiciously, than by the Right Honorable the Lord *Brouncker*, President of this Society. For I do not think it hard to conceive, that Weights and Sails are powers of like Effect, and reducible to the same Principle; so as if a Body have moved in double velocity, when drawn by a quadruple weight;

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weight ; and in triple, when by a noncuple weight ; I doubt not but the same will hold in Sails, or other impellent Powers of the same proportions.

And for the further clearing or easier trying hereof, I offer two small Machinements heretofore made in this Society. : The one, to measure the Velocity of the Wind, and the other its Power or Equivalency to Weight ; whereby it did and will appear, when the  
wind

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wind is of double velocity, it will stir a quadruple weight ; and the like in other cases according to the proportions of Roots and Squares above mentioned. The same may also be seen even in any good Turnspit-Jack, where a quadruple weight makes double Velocity (at the same distances of Time from the beginning of the Motion) both in the time of the Weights descent, as also in the Revolutions of the Fly, and each  
in-

termediate Wheel. Now perhaps the reason of these Phænomena may be here expected; to which I answer, that the many parallel Instances above and hereafter mentioned, do, like concurrent witnesses, prove the premisses, at least as to any practical use. And as for giving other reasons (which I take to be Explaining this Subject from the very first Principles of *Atomical Matter*, and *Motion*) I leave it to discourse, as

as too long for this Exercise.

**The Second Instance**

*Is in the Strength of Timber, &c.*

**L** Et there be Square Rods or Pieces made of any Clean Timber, or other Materials, whose Ends let be supported with convenient Blocks or *Fulcra*: These Rods in Experience will bear weight hung in the

[ 42 ]

the middle of them, according to the proportion of their lengths or distance, between the *Fulcra*; that is to say, a Rod A. being of double length to the Rod B. will bear  $\frac{1}{2}$  the weight which B can bear; and being of triple length, it will bear one third; & sic de ceteris. Again, let two of those equal and alike square Rods be placed one upon the other (so as to touch and fit,) then the two together shall bear 4 times  
as

[ 43 ]

as much as one alone, and three of them, placed as aforesaid, shall bear nine times as much, and so on in proportion of Roots to Squares. Again, lay the same two Rods side by side, to each other, then they shall bear but double, three shall bear triple, and so forward, in *Arithmetical proportion*. From whence it follows, that four of them placed square, shall bear eight times as much as one alone. But if the same four  
Rods

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Rods taken as One, being of double length making an Octuple quantity to One, they shall bear but four times the weight of One alone. So as two like pieces of Timber, that are incubical or triplicate proportion of their Sides, are strong but according to duplicate proportion, or the Squares of their respective Sides; and consequently, to have like Vessels (differing in Content as the Cubes of their like Sides)

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Sides) equally strong, the Timber of which they consist must be *Quadrato-quadratic*; that is to say, a Ship of 400 Tuns, equally strong with one of 50, must have not only 8 times as much Timber in it, but 16 times; which is seldom or never done. Which defect is the true Reason, why great Shipping is both Dearer and Weaker than small Shipping, (no Ship in the world being so strong as a Nutshell;) I say,  
*Weaker,*

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*Weaker*, for what is here said; and *Dearer*, for what shall be said hereafter in the sixteenth Instance of Masts, Diamonds, &c. And on the other hand, if the Timbers were Quadrato-quadratic, then the Ship of 400 Tuns would be loaden with her own Materials; if the Ship of 50 Tuns were not over-timbered.

Now, for not well understanding these matters, many men designing Engines

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gines of strength, do make Models of such Machinaments by a Scale (suppose wherein an inch represents a foot,) by which the Model is the  $\frac{1}{1728}$  part of the Engine intended: And thereupon they conceive, that if the Model be strong enough to bear  $\frac{1}{1728}$  part of what the great Machinament is intended to bear, that then the said great Machinament will be strong enough. Whereas indeed the Model must bear the full



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full  $\frac{1}{144}$  of what is intended for the great Machinament; otherwise great mischiefs will appear in the Work. Wherefore the Square of the Linear Difference between the Model and Engin, is the measure and way of trying the strength and sufficiency sought for: The ignorance whereof hath made many a poor Projector. Upon these Principles, a Cask which will hold a Tun, ought to have 16 times as much Timber in it,

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it, as the Cask which holds onely a Barrel, or  $\frac{1}{8}$  of a Tun; provided one be as strong as the other (which is not usually seen.) For the bigger Vessels, *Carts*, &c. they are usually the weaker compar'd with the strength of the lesser; which appears also in *Animals*, whose strength is as the Square Roots of their weights and substance, *viz.* if 1728. Mice were equiponderate to one Horse, the said Horse is but  $\frac{1}{144}$  part as strong as  
D all

[ 50 ]

all the said Mice.

From these considerations the Scantlings of *Timber* in Buildings must be adjusted; as for example, Let the Walls of any Room be infinitely, that is, sufficiently strong; let the length and the breadth of the Room be given: Next, suppose the Room is to be made so strong, as that every foot and a half square shall bear a Man, and so, that  $31\frac{1}{2}$  square feet should bear a Tun weight, (reckoning

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reckoning 14 men to the Tun:) Lastly, let the strength of the Timber be also given. Now the Questions are, to find the Scantlings of the Girders, Gise, &c. first in square pieces, and afterwards by altering the Squares into more advantageous oblong Sizes; as for example, Let the Room be supposed 26 foot long and 20 broad, viz. 520 foot in the *Area*, and able to receive about 250 men, and to bear about

D 2          bout

[ 52 ]

about 16 Tuns. Suppose the Timber be such, as whereof a Rod of an inch square, and 20 foot long, will bear  $\frac{1}{20}$  part of an hundred weight; or, that 20 such Rods, or a Board of 20 inches broad, and 20 foot long within the walls, an whole hundred weight; and so the whole Floor consisting of about 16 such Boards, but 1600. Now if the same Board were planck of 4 inches thick, it would bear 16 times 1600 or 256  
hun-

[ 53 ]

hundred weight: If 5 inches, 400 hundred weight: But the whole weight designed being but 325 hundred, some size between 4 and 5 inches thick will suffice in this case, where we suppose the Floor to be of planck without Gise or Girder. Next, suppose instead of this Planck there be used Gise of double thickness to the said Planck, and placed at quadruple distance; I say, the Effect and Strength will be  
E. 3 the

[ 54 ]

the same with half the stuff. And I also say, that one Girder alone of 18 inches square, and 20 foot long, is near Equivalent to the 17 Gises of 9 inches deep, and  $4\frac{1}{2}$  broad-abovemen- tioned; which Girder has but half the stuff which the Gise had; as the Gise did contain but half the stuff, which the  $4\frac{1}{2}$  inch-Plank first mentioned did contain. Which saving of stuff is the reason of dividing Plank into Girders,  
Gise,

[ 55 ]

Gise, and Board. Where- note, that these Proporti- ons and Scantlings are not offered as exact and best for practice, but onely to intimate the method of in- quiring into these matters so useful in the world.

### The Third Instance

*In the Oars of a Boat, &c.*

**T**O determine or make a good estimate of the power of *Oars*, I first, for  
D 4 easier

[56]

easier calculation, suppose a Paralellipedon-Boat or Vessel, of breadth fit for a pair of Skulls, viz. of about 5 foot broad, and of length sufficient for 9 such Skulls or Oars, viz. about 30 foot long, and one foot deep, and to draw but three inches water. Next, I suppose, that every Skul-ler with his Skulls and Bench, &c. their weight to be equivalent to three Cu-bical foot of water; so as every pair of Skulls (with its

[57]

its appurtenances) depref-  
ses or sinks the Vessel  $\frac{1}{50}$  of a  
foot, or about  $\frac{1}{4}$  of an inch.  
Now, suppose also a smooth  
calm standing water, in  
which one Rower will row  
this Vessel 12000 foot, or  
above two miles in an hour  
or 3600 seconds; I say then,  
that, if one *Remex* or Skul-  
ler move 12 quarters or 3 inch-  
es draught, 12000 feet for-  
ward in 3600 seconds; then  
4 like Rowers shall move  
the same Vessel, drawing  
15 quarters, or  $3\frac{3}{4}$  inches

D 5 of

[ 58 ]

of water, the same 12000 feet, in 1800 seconds *plus* 360 seconds, or in all, 2160 seconds: And that 9 shall row the same Vessel, as the Root of 21 to the Root of 108, which is, as near 3 to 7; or in  $\frac{2}{7}$  of the time that one Rower alone could have done the same. Again, suppose each Oar lengthened from two to three, and that as many strokes are made in the same time as before; then the Velocity shall increase proportionably. But

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But suppose, that the Oars remain of the same length, but that the *Blade* be doubled; then the Velocity shall increase but according to the Roots of that doubling, or as 10 to 7, or 7 to 5, &c. supposing still the same number of strokes, within the same time, in every Case or Experiment.

Again, suppose these Experiments be made not in still water, but in water which runs 6000 foot an hour;

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hour; then, *against* the stream the Velocity will be lessened by one half, and accelerated answerably *with* it.

Lastly, if the said water be so rough, as that the Vessel heaves and sets, suppose 20 degrees of the Quadrant in it; then, forasmuch as the Boats way will be encreased as much as the *Tangent* of 20 degrees exceeds the *Radius*, the way or Velocity of the Boat must abate proportionably.

The

[ 61 ]

### The Fourth Instance

In the *Motion of Horses.*

Suppose an Horse can travel 5 miles an hour with 200 pound burthen on his back; then with half the said burthen he shall travel 7; and with double but three miles and a half. Again, suppose a Horse with 200 pound burthen can endure to travel 10 hours *per diem*; then with

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with half the same burthen he may endure 14 hours, and with double but 7 hours. Lastly, suppose a Horse (as Race-horses) can run after the rate of four miles in  $\frac{1}{8}$  of an hour, or 32 miles *per* hour, then they can run about 6 miles  $\frac{1}{28}$  in  $\frac{1}{4}$ , or after the rate of  $24\frac{1}{7}$  miles *per* hour; and in one half an hour can run 8 miles, or after the rate of 16 miles *per* hour; and in a whole hour can run  $12\frac{1}{4}$  miles; and in 2 hours can

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can run 16 miles, or 8 miles *per* hour; and in 4 hours can run 24 miles, at 6 miles *per* hour; and in 8 hours 32, or 4 miles *per* hour; and in 16 hours may go 48 miles, or 3 miles in an hour. All which agrees well enough with Experience.

The



The Fifth Instance,

In Mills.

Where the wind blows, suppose, on a Saw-mill, in double Velocity, there the Saw-mill, which carried but one Saw, shall carry four; If treble, shall carry nine. And the like is true of water gushing out upon the floats of Under-shot Mills; as may be seen in the Stampers of Paper-Mills, the Stocks of Fulling-

Fulling-Mills; and other Works of the like nature.

The Sixth Instance,

In Gunpowder.

The way of a Bullet, shot out of a good Gun, is as the square Roots of the quantity of the Gunpowder fired; I say, of Powder fired, because what goes out unburnt, goes rather as Shot than Powder; and the Length of Guns signifies only the constraining of

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of the Powder within the Lines of Direction, till it be all fired : The use of hard ramming and screwing of Guns, being also the same ; and the excellency of Powder being to fire quick, and before it goes out of the Gun. I say therefore, the Velocities caused by Gun-powder are as the Roots of the Powder fired, that is to say, 4 pound of Powder, all equally fired within the Piece, shall carry a Bullet twice as far as  
one

[ 67 ]

one pound shall do ; and in *Time*, as 10 to 7 ; which last mentioned numbers are the Roots of the double distances afore-mentioned. Now, if the Capacity of the Concave of Guns ought to be, as the Weight of their Bullets or Powder ; then, if the just length of any one Gun hath been well found by good Experimentation, then may also be known the length of every Gun for every Bullet respectively. As, for example, suppose

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pose a Gun, that carries a Ball of 5 inches Diameter, be 10 foot long in the Concave, then the Content of the said Concave will be 3000 Cylindrical inches. Now the question is, how long must the Piece be, which carries a Bullet of 7 inches Diameter? I say, that forasmuch as the Weight of the 5 inch Bullet, to that of 7, is as 125 to 343; the Concave of the greater Gun must be in the same proportion to

3000.

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3000, viz. 8232 like inches, so as it may contain and fire a proportionable quantity of powder: Which 8232 being divided by the Area of the Bullet, 49, the Quotient will be 168 inches, or 14 foot; that is (to speak shortly and plainly) *The Length of Guns must be measured by the Diameters of their respective Bullets.* I cannot say, I have tried the effects of Gunpowder to be in the abovemention'd proportion, but have credibly heard

heard

heard it to be so; and because of the Similitude of Sails,Weights, Knocks,and the other points above described, unto this of Gunpowder, I believe it; and recommend it to your further thoughts and experience.

**The Seventh Instance.**  
*Of Sounds.*

**L** Et there be many *Equal Sounds*; I say, that the Distances, at which they may

may be heard, are the Roots of the Numbers of such Sounds. For, four Musquets will be heard twice as far as one, and nine thrice; and so of the rest. By which reckoning, the hearing of some of our Fleets Engagement with the *Dutch* even to *S. James's Park* near this City is easily solved; and the truth of that Observation doth reciprocally countenance this Doctrine. For suppose both Fleets (consisting

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ing of two hundred Ships great and small ) had about 12000 pieces of Ordnance on board them, which at a *Medium* suppose to be Demi-Culverins: Suppose also, that a Demi-culverin, with the same circumstances of Wind and Air, may be as easily heard five miles, as the said Engagements were heard 160 miles. Then I say, that 1024 of the said 12000 Guns firing together, or very near the same time, might

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might ( as they were ) be well heard 160 miles; and that about 4000 such Guns might as well be heard 300 miles, as one Demi-Culverin five miles; which last point I add, to prevent the unbelief of a probable matter, when it shall happen. Now what effect this had in the *Popes* Presage of the Battel of *Lepanto*, I know not.

E The

The Eighth Instance  
Of Smells

I Say the same of Smells, viz. that the Distances at which they are perceived are the Roots of the Quantity of the Matter out of which they are emitted; which Doctrin I apply to solve what I once did hardly believe, viz. that Ships coming from *America* towards *Portugal*, did smell the Rosemary and other odori.

odoriferous herbs 60 miles off from the Land : The which seems not only credible, but very likely. For, if a foot square of a Rosemary-Field may be smelt one Perch or Rod (whereof 320 make a mile,) then about 8000 Acres of Land, whereon such sented Plants do grow (or a piece of Land about 4 miles long, and 3 miles broad; or 6 miles long, and 2 miles broad) may be smelt 64 miles : And 72000 Acres  
E 2 of

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of the like Land, or a parcel of such Land about 11 miles square, may be smelt as many *leagues*, or near 200 miles. And this Consideration I pitch upon, as one of the grounds whereupon I would build a Doctrine concerning the Influence of the Stars, and other Celestial or remote Bodies upon the Globe of the Earth, and its Inhabitants, both Men and Brutes.

The

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## The Ninth Instance

Concerns *Visible Objects*.

I Say also, that four equal and like *Candles* will give light but twice as far as one, and 9, thrice as far; and that 16 will also enlighten but 4 times as far as one, &c. And if a Flag or Ships-Vane of a yard square may be seen a league off at Sea, it must be 2 yards square, or 4 square yards

E 3 to

to be seen 2 leagues, and so forward. But whoever will make experiment hereof, must first consider, how many miles in thickness of a Middling, Clear, and Diaphanous Air do make an Opaque. For we find, that although a very thin plate of clear Glafs seems to hinder our sight of near Objects but very little; yet we also know, that great number of them (suppose one hundred) can scarce be seen through at all.  
Here-

Hereunto also must be added the Consideration of the Convexity of the Earth; and then I doubt not, but this Doctrin (of Roots and Squares) rectified and corrected with the two additional Considerations last mentioned, will hold concerning Visible and Lucid Bodies, as was above propounded.

E 4 The



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**The Tenth Instance,***In the Time of the Vibration  
of Pendules.*

**T**He times in which the Returns of a *Vibrating Pendulum* are made, are the Roots of the Distances between the Center of the Pendulum, and the Center upon which it moves. I shall need to make no application of this Truth, since we all enjoy the

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the benefit of it in our more regulated Clocks and Measures of Time, which are now in common use, and from whose Improvements we may most hopefully expect a better measure of *Longitude* upon the Surface of the Earth. The further uses which may be made hereof, (it being a very simple and examinable Experiment) is to witness and give evidence to other the more abstruse and complicate Positions, which

E 5 are

are of the like and parallel Nature.

**The Eleventh Instance**

*In the Life of Man, and its Duration.*

**I**T is found by Experience, that there are more persons living of between 16 and 26 years old, than of any other Age or Decade of years in the whole life of Man (which *David* and *Experience* say to

to be between 70 and 80 years:) The reasons whereof are not abstruse, *viz.* because those of 16 have passed the danger of Teeth, Convulsions, Worms, Rickets, Measles, and Small-pox for the most part: And for that those of 26. are scarce come to the Gout, Stone, Dropfie, Palfies, Lethargies, Apoplexies, and other Infirmities of Old Age. Now whether these be sufficient reasons, is not the present Enquiry; but

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but taking the afore-mentioned Assertion to be true ; I say, that the Roots of every number of Mens Ages under 16 ( whose Root is 4 ) compared with the said number 4 , doth shew the proportion of the likelihood of such mens reaching 70 years of Age. As for example ; 'Tis 4 times more likely, that one of 16 years old should live to 70, then a new-born Babe. 'Tis three times more likely, that one of 9 years old should

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should attain the said age of 70, than the said Infant. Moreover, 'tis twice as likely, that one of 16 should reach that Age, as that one of 4 years old should do it ; and one third more likely, than for one of nine. On the other hand, 'tis 5 to 4, that one of 26 years old will die before one of 16 ; and 6 to 5, that one of 36 will die before one of 26 ; and 3 to 2, that the same person of 36 shall die before him of 16 : And so forward according

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according to the Roots of any other year of the declining Age compared with a number between 4 and 5, which is the Root of 21, the most hopeful year for Longævity, as the mean between 16 and 26; and is the year of perfection, according to the sense of *Our Law*, and the Age for whose life a *Lease* is most valuable. To prove all which, I can produce the accompts of every Man, Woman, and Child, within a certain Pa-  
rish

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rish of above 330 Souls; all which particular Ages being cast up, and added together, and the Sum divided by the whole number of Souls, made the Quotient between 15 and 16; which I call (if it be Constant or Uniform) the Age of that Parish, or numerous *Index* or Longævity there. Many of which Indexes for several times and places, would make an useful Scale of Salubrity for those places; and a better Judg of Ayres than  
the

[ 88 ]

the conjectural Notions we commonly read and talk of. And such a Scale the *King* might as easily make for all his Dominions, as I did this for this one Parish.

**The Twelfth Instance**

In *Musick*.

**T**Ake a *Musical String*, one end thereof being fastned; hang unto the other (over a convenient Bridg) any weight which may strain it to some grave Musical Tone or Note; then  
set

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set some other string of near the same length, Unifone thereunto. Lastly, instead of the first weight, hang to the first String the Quadruple of the same weight; and it will appear, that the String with the quadruple weight shall yield a Tone of an 8<sup>th</sup> or Diapason above it self, when singly charged. The reason is, because the quadruple weight doubles the number of Vibrations, (2 being the Root of 4 :) And for that the *Ratio Formalis*

*malis* of Tones lieth in the number of the Vibrations ; and of the Diapasons, in the doublness of such numbers. By the same Method of hanging-on several weights at one end of the same String, all Tones may be produced, of which such String is capable. The Tones or Notes also of like Bells and Drums do follow the same proportions of their Tension and Mettal, so as able Artists can cast Bells in Tones assigned.

The

The Thirteenth Instance,  
Of Fire and Spirits.

Let a Cylindrical Flat-bottom Vessel be filled with Water, and let it be tried, in what time one Lamp or Candle would make the water boyl through, or come up to its greatest heat : Then see, in how much lesser time, 2, 3, or 4 more like fires will hasten the same effect. I can-

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cannot speak positively hereof, but know from several Observations, that the Acceleration abovesaid shall not be made in Arithmetical Proportion; forasmuch as I know, that in Fire-works great Fires are more profitable than small; as in Brewers Coppers, and Iron-works may be seen; wherein double Fires produce more than double dispatch or advantage. I shall therefore suspend this matter, and pass to the measuring

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ring of the *Spirituousity of Liquors*, or in what proportions several Liquors contain more or less of inflammable or ardent parts. Now in this case I conceive, the Consideration of Roots and Squares is also material; for I understand by strength or multitude of Spirits, the Space, greater or lesser, into which such Liquors will be rarified, or will fill with Spirits: As for example, if a Pint of Water rarified into Va-  
pour

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pour will fill a Globe but of 3 foot Diameter; and a Pint of rectified Spirit of Wine will fill a Globe of six foot diameter, or 8 times as large as that of Water; I shall say, that there is 8 times as much Spirit or Vapour in one as in the other. But if these Liquors were put into open Lamps or Vessels, there the space in which the Spirits rise, are the Roots, whose Squares do shew the Spirituosity of those Liquors: *Ex. gr.* Let there

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there be a Lamplike Vessel of common *Aquavita*; in which place a Wick as high as the same will burn by the rising of the Spirit unto it, suppose an inch above the surface of the Liquor: Now, let there be a like Equal vessel with such a Spirit, as will rise up higher, suppose to a Wick placed two inches above the Surface; in this case, I say, that the latter Liquor is quadruple in strength or extent of Spirit to the former;



mer ; for 'tis certain, that as the Spirit riseth double upwards, so also it emitteth or rarifieth it self double also sideways ; and consequently the quantity of the Spirit or Vapour must be quadruple ; and so of other proportions.

The

The Fourteenth Instance,

*Of Rising and Falling Bodies ; but particularly of Waters in Pumps and River-streams.*

Let it be observed in the Transparent Pipe of a Forcing Pump, at how many stroaks the Water is forced from the Bottom to the Top ; and let as many marks be made at the several places unto which the  
F Water

[ 98 ]

Water mounted at every stroak (which stroaks we suppose to be all in Equal Times;) it will appear, that all the said Divisions will be according to the Proportions or the Logarithms above-mentioned. As for the Descents and Accelerations of falling Bodies, the *Times* are the Roots of these *Spaces*, which they fall in the said times respectively. The great effect whereof we see in *Overshot-Mills*, where a little water falling

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falling upon a Wheel of a large Diameter, produceth wonderful Effects; the which may be well computed upon the Principles we hold forth.

Waters also have greater forces in the above-mentioned proportions, as the hole or place whereat they issue is lower from their Surface; as may be seen in all Breast-and Undershot-Mills; where it is pleasant to divide the Sinking of the water into Equal Spaces

F 2

ces

[ 100 ]

ces, and to count the Clacks, Revolutions or Stroaks made within the Time of the waters sinking every such equal Space; for therein the above-mentioned Logarithmes may also be observed.

Unto this head may be referred the *Leakage of Ships*. For let there be a hole in a Ship somewhere under water; then let it be seen, what water comes in at the said hole, within any space of Time; then let the

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the like hole be made at double the perpendicular distance from the top of the water, and there shall come in four times as much as at the upper hole; and let a third be at three distances, and that shall admit 9 times as much, &c. Again, let there be two Equal holes or Leaks in a Ship, the one at Head, and the other at Stern, and let the Ship be in motion; then the Leakage at the Head is composed of the pressure of

E. 3. the

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the water from the Surface, and of the Ships Motion together. Moreover, if the Ship make double way, the Leakage will be quadruple; if treble way, noncuple, &c. Wherefore to stop Leaks *afore*, the Ship must stop its motion, lye by, or bear up to go with the Wind and Sea, &c.

Lastly, I shall add, that the Swiftnesse of Waters or River-streams, are the Roots of the Power that causes them; which causes

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causes are Steepness or Descent in a sharper Angle from the Perpendicular. Wherefore knowing by observations, what degree of Steepness causeth any degree of Swiftnesse; hereby, and by our Doctrin, the Height of ground where any River riseth above its fall into the Sea, may be computed.

F 4

The

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**The Fifteenth Instance,***In the Blast of Bellows.*

**I**N Iron-work Furnaces are the greatest and most regular moving Bellows that are any where used; the which are commonly turned by the evenest overshoot Wheels. Now the Times wherein these Bellows rise and fall, are Roots of the Strength of such Bellows-blast upon the

[ 105 ]

the fire; for rising in double Quickness admits double air in the same Time; which being in like manner squeezed out again, double Quickness makes double Expulsion, and consequently double Swiftnes; (the whole passing through the same Twire-pipe in half the time;) and double Swiftnes makes quadruple effects upon the fire or Furnace, as aforesaid.

F. 5. The

The Sixteenth Instance,  
In the Price of several Com-  
modities.

Suppose a Mast for a  
small Ship be of 10  
inches Diameter, and as is  
usual, of 70 foot in height,  
and be worth 40 s; then a  
Mast of 20 inches through,  
and double length also,  
shall not onely cost eight  
times as much, according  
to the Octuple quantity of  
Tim-

Timber it conteins, but  
shall cost 16 times as much,  
or 32 l. And by the same  
Rule, a Mast of 40 inches  
through shall cost 16 times  
32 l. or 516 l. Of which  
last Case there have been  
some instances. But where-  
as it may be objected, That  
there are no Masts of  
four times 70, or 280 foot  
long, I still say, that the  
Rule holds in common pra-  
ctice and dealing. For, if  
a Mast of 10 inches thick,  
and 60 foot long, be worth  
30 s.

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30 s; a Mast of 20 inches throughout, and 80 foot long, shall be worth 15 l. And a Mast of 40 inches thorough, and 100 foot long (not 280 foot) shall be worth near 100 l.

Moreover, suppose *Diamonds* or *Pearls* be equal and like in their Figures, Waters, Colours, and Evenness, and differ onely in their Weights and Magnitudes; I say, the Weights are but the Roots of their Prices, as in the Case a-fore-

[109]

foregoing. So a Diamond of Decuple weight, is of Centuple value. The same may be said of Looking-glass-Plates. I might add, that the Loadstone A, if it take up 10 times more than the Loadstone B, may be also of Centuple value.

Lastly, A Tun of extreme large *Timber* may be worth two Tuns of ordinary dimensions; which is the cause of the dear-ness of great Shipping above small; for the Hull  
of

of a Vessel of 40 Tuns may be worth but 3 *l.* per Tun, whereas the Hull of a Vessel of 1000 Tuns may be worth near 15 *l.* per Tun. From whence arises a Rule, how by any Ships Burthen to know her worth by the Tun, with the Number and Size of her Ordnance, &c.

The

The Seventeenth Instance,

In Mill-Dams, Sea-Bancks, and Bulwarks of Fortresses.

Suppose any Wall, Dam, or Banck, to be just sufficient to keep out or resist the Sea, or other Stream against the appulse of its waters, being of a certain force; I say, that to make this Wall or Damm strong enough against a double



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double swiftness of appulse, it must be augmented by quadruple thickness; and if it must be made sufficient against the greatest violence which ever was observed, then that violence being known, is the Root of the number by which the Walls thickness must be augmented.

So Cannon-Bullets do Execution or batter in *duplicatâ ratione* of their swiftness; and therefore Ramperts must be strong  
and

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and thick in *duplicatâ ratione* of the said swiftness, which depends upon the Distance of the Battery, and the degrees of Tardation, which Bullets make in every part of their way between the Gun and the Rampert, which they are to batter. Where note, that Bullets commonly beat out a Cone of Wall, whose *Vertex* is in the Bullets Entry, and like the Conical *Fovea* to be seen in the Sand of an Hourglass.

The

[ 114 ]

**The Eighteenth Instance,**

In the *Compression of Yielding and Elastic Bodies*,  
as Wooll, &c.

Suppose some Cylindrical or other parallell'd sided Vessel, fill'd with Wool, or Down, or Feathers, or other *Elastic Materials*; let the same be covered with a moveable Head (such as in pressing of Pilchards they call a Buck-

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Buckler;) then first observe, how low the Buckler descendeth by its own weight; and then upon this Head or Buckler lay a triple weight, to make the whole quadruple, and it will appear, that the Buckler will sink but just as much lower; and being Noncuple, another like Space lower: So as the several Spaces of Depressions are the Roots of the depressing Powers. From hence may be seen, how the

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the Force must be increased at every Turn or Thred of a Screw-Prefs; which being done according to the proportions here understood, I doubt not, but a Light Substance with a convenient *Apparatus*, might be compressed unto the Density and Weight even of Gold. But, that Silver might be so condens'd, I made no question, till I heard of some Anomaly in the practice, which I must better consider of. The  
further

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further Truth whereof doth appear in the *Under-water-Air* within the Vessels of *Water-Divers*, who the lower they go, do find their stock of Air more and more to shrink; and that according to the Roots of the Quantities of the super-incumbent Water or Weight. In like manner take a Bow, and hang any weight to the middle of its string, and observe how low it draweth the said string. Now, if you shall  
qua-

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quadruple the same weight, it will draw down double the first distance, and nonuple will draw it down treble, &c. So as in a drawn Bow, let the Arrow be divided into *quocunque partes*, each equal part of the Tension carrieth the Arrow to an Equal Distance, notwithstanding each equal part of the Tension was made by Unequal power, and that each equal Space or Part also of the Arrows first flight requires  
 Unequal

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Unequal Force, *viz.* least strength at first, and most at last; and that, in the proportion first mentioned. So in the *Fuze* of a Watch, the greatest strength of the Spring is made to work upon the shortest *Vetis*; and the least upon the longest, so as to equalize the whole. The like also happens in the *Traction* of *Muscles* upon two Bones with a turning Joynt between them; which Bones and Muscles make a Triangle,

angle, whereof the Muscle is the Base, subtending the Angle-Joynt. Now in the working, the Muscle is strongest, when the *Vectis* is smallest, as lying most obliquely; and *vice versa*, when the Muscle and moving Bone come to make a right Angle.

An

*An Appendix*  
OF  
*E L A S T I C I T Y.*

**H**AVING done with the Consideration of duplicate and subduplicate Proportion in *Elastic* Bodies and Materials, I hope it will not be amiss to subjoyn a short Appendix of *Elasticity it self*, whereby to draw forth the better  
G thoughts

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thoughts of other men for Countenance or Correction. Wherefore I say as followeth; *viz.*

First, Supposing every *Body* to have a *Figure* or *Positure* of its own, out of which it may be disturbed by *External Force*; I say, that *Elasticity* is the power of *recovering* that *Figure*, upon removal of such *Force*.

2. I think it easiest to consider *Elastic, Springing,* or *Resilient Bodies*, as *Laminae,*

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*minæ, Laths, or Lines*; so as a streight Lath, being by force bent *circularly*, doth upon the removal of that *Force*, return to be streight again by its *Elasticity*; and a *Circular Hoop* being forced streight, leaps back into its own crookedness by its *Elasticity*.

3. *Elastic Bodies* in their returns do overshoot their own Natural *Positure*, and vibrate *cis citrà* the *Point* they seek, as doth a *Pendulum*, or *Magnetic-Needle,*

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*Needle*, till at length they rest; the one in his *Perpendicular*, and the other in his *Meridian*.

4. An *Elastic Body* is a gross *Tangible Body*, which is made of *Corpuscles*, or the smallest Bodies that can possibly be *seen*; and these *Corpuscles* are made of *Atoms*, or the smallest bodies in Nature (such as whereof a *Million* doth not perhaps make one of the *Corpuscles* last mentioned.)

5. I

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5. I know no reason, why we may not, upon occasion, suppose *Atoms* to be of *several Figures* and *Magnitudes*, provided we suppose them *immutable*, such as *Corpuscles* are not; gross tangible Bodies being very mutable by the various *Additions* and *Dejections* that befall them.

6. I suppose in every *Atom* *three such points* as we all see and know to be in the *Globe of the Earth*, and in every *Magnet*, viz. *two*

G 3 Poles

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*Poles* in its *Superficies*, and a *Central* point *within* its *substance*, which I call its *Byas*. The *Heavens* also visibly have their *Poles*, and must have a *Center of Gravity* or *Magnitude*, or some other *Central* and *pre-dominant Point*.

7. I suppose every *Atome* may move about his own *Axis*, and about other *Atoms* also, as the *Moon* does about the *Earth*; *Venus* and *Mercury* about the *Sun*; and the *Satellites*  
*Jovis*

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*Jovis* about *Jupiter*, &c.

8. I suppose, that the *Byas* of one *Atome* may have a tendency towards the *Byas* of another near it, and that the *Byasses* of many *Atoms* may tend to some common point without them; as we see in *Electrical Bodies*, and in the *Globular drops* of *Water* and *Quicksilver*, and all *Mucilaginous Substances*.

9. I suppose, that all *Atoms* have, like a *Magnet*,

G 4 two



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*two Motions*, one of *Gravity*, whereby it tendeth towards the Center of the Earth, and the other of *Verticity*, by which it tendeth towards the Earth's Poles, and whereby Magnets joyn to each other by their *Opposite Poles*.

10. All Atoms by their Motion of *Verticity* or *Polarity*, would draw themselves, like Magnets, into a streight Line, by setting all their Axes in *directum* to each other; did not the  
Moti-

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Motion of their respective Byasses towards each other, and towards other Points, curb them into a *Triangle*, whereof the *Two Axes* of *Two Atoms* are two sides, and the distance between the Byass of each making the third side: Wherefore I call the *Polar Motion* above-mentioned, the Motion of *Rectitude*; and the Motion of the *Bisses*, the Motion of *Angularity* or Curvity, or the Angular or Curve Motion.

II. I

II. I suppose, that all these Motions may be of different *Velocities*, and that by *Contra-colluctations* they ballance each other, sometime into *seeming* rest: I say, *seeming*, because perhaps there is *no* rest in Nature.

Lastly, I might suppose (even without a Metaphor) that Atoms are also *Male* and *Female*, and the *Active* and *Susceptive* Principles of all things; and that the above-named *Byasses* are the

the Points of Coition: For, that *Male* and *Female* extend further than to *Animals*, is plain enough; the fall of *Acorns* into the ground, being the Coition of Oaks with the Earth. Nor is it absurd to think, that the words in *Genesis*, [*Male and Female created he them*] may begin to take effect, even in the smallest parts of the *first Matter*. For although the words were spoken onely of *Man*; yet we see they certain-

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certainly refer to other Animals, and to *Vegetables* in manner aforesaid, and consequently not probably to all other *Principles of Generation*.

### *Conclusion.*

To Conclude, I hope I may say, that these my *Principles*, are *Principles indeed*; for there can be no *fewer* nor *easier* than *Matter* and *Motion*. My *Matter* is so simple, as I take notice  
of

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of nothing in each Atome, but of *three such Points* as are in the Heavens, the Earth, in Magnets, and in many other Bodies. Nor do I suppose any *Motions*, but what we see in the greater parts of the Universe, and in the parts of the Earth and Sea.

Again, all the *Motions* I fancy in my Atoms, may be represented in gross *Tangible* Bodies, and consequently may be made *intelligible* and *examinable*.  
More-

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Moreover, I hope none of my Suppositions are inconsistent with each other, nor do necessarily infer any absurdity or falsehood.

And lastly, I hope they solve all the *Phænomena* of *Elasticity*, and, as I think, of *Hardness*, *Fixedness*, *Tenacity*, *Fluidity*, *Heat*, *Moisture*, *Fermentation*, and the rest. All which is humbly submitted to the Censure of this *Society*; whose *Atoms* or inseparable Members I wish may happily  
Con-

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Conglomerate, and Unite themselves into the most fixed and most noble Bodies amongst the Sons of Men.

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*FINIS.*

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