MATHEMATICS.

I am fully aware of the difficulties which I shall have to encounter in trying to enlist your interst in what is commonly called "a dry subject." The usefulness of the study of Mathematics sounds like a paradox to the superficial observer. An ordinary man cannot help putting such questions as :—

(*a*) why should we bother our heads about the 47th proposition of Euclid's First Book ?

(*b*) of what use in the world can the Binomial Theorem be ?

(*c*) Why should we spend a considerable portion of our life at a b, c and longs (*f*) ?

(*d*) What is the use of dealing with the Greek Mathematical signs ?

1. The inability to answer questions like these or the apparent uselessness of

Mathematics makes this study very unpopular.

2. Another reason why it is disliked is that it is a very hard subject which taxes both the memory and the intellect; it is difficult to understand and more difficult to remember. To read it is not like walking on a smooth paved road; but there the path is, so to speak, both slippery and rough, presents many stumbling blocks and rubs in the way.

3. A third reason why Mathematics is felt so heavy and tedious is that generally it is not administered in proper doses or in an agreeable form; in other words, teachers do not always try to make it attractive. Carbon dioxide swallowed as in soda-water, is conducive to health; but inhaled, it injures the system. Just so, Mathematics does us good only if taken or studied in the proper way.

Students as a rule, complain against the University because Mathematics is made a compulsory subject in some examinations, they blame the Syndics and have all sorts of hard names to give to Mathematical writers.

To begin with, let us for the sake of argument assume that Mathematics has really no reward to offer, has nothing to pay. But, dear friends, let us not in whatever we undertake, be led and guided by a desire of reward. This mercenary spirit ought to be checked. The event or fruit of any action ought not to influence us; let us do whatever we engage in, goaded by a sense of duty and not drawn by the bright future:—

If duty calls to brazen walls,
How base the fool who flinches.

Let us work into life the following advice of the author of Bhagwad Gita:—

"..... Find full reward
Of doing right in right! Let right deeds be
Thy motive, not the fruit which comes from them.
And life in action! Labour! Make thine acts,
Thy piety....."

Learn to acquire knowledge for its own sake; hunger and thirst after knowledge. Learn a lesson from the life of Old King Ulysses who with one foot in the grave wooes knowledge and asks his followers.

To follow knowledge like a sinking star,
Beyond the utmost bound of human thought.

The assumption above made is far from being correct. The advantages of Mathematics are very many. They do not lie on the surface, but are hidden and concealed:—

(*i*) Mathematics is like the ocean rough, boisterous, and fearful on the surface; but having precious pearls, and gems of the purest ray serene at the bottom; or

(*ii*) it may be compared to the statues of the old satyrs and sileni of Greece; repulsive figures to look at but enclosing within them the finished and fascinating statues of the most beloved gods of the Greeks.

(*iii*) Like the solar light it appears quite colourless to the unthinking multitude, while it is in reality composed of the colours of the rainbow.

Mathematics (*Gr Mathe-Matike*) in its original sense signifies "skill, knowledge or science." And in all its subsequent developement it has had the idea of "skill, knowledge or science" always underlying it. It is in no small measure to *Mathematics* that the world

owes its Sciences of Astronmy. Optics, Acoustics, Statics, Dynamics, Hydrostatics, Hydrodynamics, Thermodynamics, Magnetism, etc; and the Arts of Navigation, Engineering, Arceitecture, and the like.

Mathematics is well called an *exact science* and a sure and certain branch of knowledge (*cf.* the phrase "Mathematical certainty.")

"Geometry," Pascal observes, "is almost the only subject in which we find truths wherein all men agree; and one cause of this is that geometricians alone regard the true laws of demonstration." So Geometry or Mathematics, we may say, has been like that solid and substantial food to Science which goes for the most part to form bone or the supporting element. According to Roger Becon, Mathematics is the "gateway and the key to other sciences." Professor Ball says—"It is interesting to note that advance in our knowledge of Physics is largely due to the application to it of Mathematics, and every year it becomes more difficult for an experimenter to make any mark in the subject unless he is also a Mathematician."

What generally happens is that the Mathematician takes the results of some

every-day observations and raises on them splendid super-structures which attract the attention of the Experimentalist, who steps forward and verifies by experiment the results thought out by the Mathematician. Then the labours of the two combined enrich the world with inventions and discoveries; give to its railways, telegraphs, balloons and what not. Happy the man who is a Mathematician and Experimentalist in one.

"The most general division of Mathematics," says Herbert Spencer, "dealing with *number* guides all industrial activities, be they those by which processes are adjusted, or estimates framed or commodities bought and sold or accounts kept. No one needs to have the value of this division of Abstract Science insisted upon."

"For the higher arts of construction," the same writer continues to say "some acquaintance with the more special division of Mathematics is indispensable. The village carpenter who lays out his work by empirical rules, equally with the builder of a Britanica-Bridge, makes hourly reference to the laws of space-relations. The surveyor who measures the land purchased; the architect in

designing a mansion to be built on it; the builder when laying out the foundations; the masons in cutting the stones; and the various artizans who put up the fittings are all guided by geometrical truths. Railway making is regulated from beginning to end by geometry; alike in the preparation of plans and sections; in staking out the line; in the mensuration of cuttings and embankments; in the designing and building of bridges, culverts, viaducts, tunnels, stations. Similarly with the harbours, docks, piers and various engineering and architectural works that fringe the coasts and overspread the country as well as the mines that run underneath it. And now-a-days even the farmer, for the correct laying out of his drains, has recourse to the level—that is, to geometrical principles.

"On the application of Mechanics (a branch of Applied Mathematics) depends the success of modern manufactures. The properties of the lever, the wheel-and-axle, etc., are recognised in every machine, and to machinery in these times we owe all production." The following is the case in England and will in no long time be the case here too:

"Trace the history of the breakfast roll. The soil out of which it came was drained with machine-made tiles; the surface was turned over by a machine-made tiles; the wheat was reaped, thrashed and winnowed by machines; by machinery it was ground and bolted; and had the flour been sent to Gosport, it might have been made into biscuits by a machine. Look round the room in which you sit. If modern, probably the bricks in its walls are machine-made and by machinery the flooring was sawn and planed, the mantel-shelf sawn and polished, the paper-hangings made and painted. The veneer on the table, the turned legs of the chairs, the carpet, the curtains are all product of machinery.

"Your clothing—plain, figured or printed—is it not wholly woven, nay, perhaps even sewn by machinery? And the volume you are reading, are not its leaves fabricated by one machine and covered with these words by another? Add to this that for the means of distribution over land and sea, we are similarly indebted. And then observe that according as knowledge of *mechanics* is well or ill applied to these ends comes success or failure. The engineer who miscal-

culates the strength of materials, builds a bridge that breaks down. The manufacturer who uses a bad machine connot compete with another whose machine wastes less in friction and inertia. The ship-builder adhering to the old model is outsailed by one who builds on the mechanically justified wave-line principle. And as the ability of a nation to hold its own against other nations depends on the skilled activity of its units, we see that on mechanical knowledge may turn the national fate."

Let us now see to whom most of the modern inventions and discoveries of which the world is so proud owe their origin?

By whom was the first *Steam-engine* made?

James Watt, a Mathematical Instrument maker.

By whom was the *clock* invented?

Galileo, a Mathematician.

By whom was the first *telescope* made?

Galileo, a Mathematician.

By whom, the Barometer?

Pascal, a Mathematician.

Who found out the amount of alloy in the golden Crown of King Hiero of Syracuse?

Archimedes, a Mathematician.

Who was it that discovered the Law of Gravitation?

Newton, the prince of Mathematicians.

In a word, directly or indirectly almost all our conveniences and articles of comfort are due to this branch of Philosophy or Science which we call Mathematics.

Professor Adams, the Mathematician foretold the existence in the heavens of satellite not known to the world before, and *then* the practical astronomer actually discovered the same.

Mathematics enables us to calculate accurately distances, billions upon billions of miles in length, as the distances of stars, etc; and it also enables us to measure magnitudes about one billionth part of a cubic inch in volume, like the size of a molecule or atom. From finite quantities it leads us on to the region of the infinite.

By Mathematics we discover some of the Universal Laws of Nature written with inerasible ink on the faces of substances by the unerring finger of the Almighty. In the lines and figures of Geometry we learn "those

characters" to use an expression of Galileo "in which the great book of the universe is written."

In Statics and Dynamics the Mathematician deals with forces varying according to different laws and in case a new kind of energy should come to light and give rise to forces obeying laws different from those which the forces of ordinary nature obey, the Mathematician will be found fully equipped to receive it; whereas the mere experimentalist if not calling Mathematics to his aid, will be at a loss how to deal with it at the first sight. Let a new fluid be discovered and its fundamental property known; it will find itself already registered in the works on Higher Hydrostatics as an old servant with specified duties to discharge.

There is a variety among individuals of all species: again the different species of the same genus are in no instance exactly alike; and they differ widely. So, I persume that different planets of the same Solar System have no monotony and the different Solar Systems are not alike in every respect. They are, in all probability governed by new laws and are blessed with new materials, new

liquids and new kinds of Energy. Mathematics embraces the properties of these new things as well as those of the old familiar ones. This is knowledge of intrinsic worth.

Its rules and laws govern the phenomena and facts that can ever take place on the background of Eternity. "The old order ceaseth, yielding place to new" but the Mathematical dogmas remain still controlling all these vicissitudes and undergoing no change in themselves.

Says Herbert Spencer—"of course as those facts which concern all mankind throughout all times must be held of greater moment than those which concern only a portion of them during the continuance of a fashion, it follows that in a rational estimate, knowledge of such facts, being knowledge of intrinsic worth, must other things being equal take precedence of knowledge that is of quasi-intrinsic or conventional worth."

Hence you can judge of the importance of Mathematics which beyond doubt, imparts knowledge of the kind of facts here alluded to.

If most people pride themselves on possessing a knowledge of Law, (Law dealing with

matters of this transient world), why should a knowledge of the eternal laws dealing with all worlds and possibly with the world to-come be disdained.

"That very law which moulds a tear,
And bids it trickle from its source,
That law preserves the earth a sphere,
And guides the planets in their course."

This law and many similar laws are treated in the works on Mathematics.

To show that the sphere of Mathematics is not confined to the physical objects alone, but extends over the mental and the psychic phenomena as well, I may refer to the distinguished writers on the Calculus of Probabilities who have applied it to *Belief* and also to Edgeworth and Jevons who have shown it to be capable of application to *Feelings*.

Milton holds that a part of the happiness of the pious will consist in the consciousness of the knowledge which they acquired in this world. If this be true, Mathematics is sure to make you happier in the world to-come, as it embodies knowledge of the widest application.

I have been discussing so far the value of Mathematics as knowledge. Now, let us

discuss its value in the way of discipline. And here, without question it holds a supreme place.

The Vernacular word for Mathematics is "*Riyazi*" and this very name signifies "pertaining to "*Riyazat*" or discipline". The study of Mathematics involves a mental exercise best fitted for strengthening the faculties.

The advantages of Physical exercise are not apparent to an ordinary Indian boy; and Physical exercise is not so pleasant to him as eatables; being ignorant of the fact that in proportion as he takes more physical exercise, he will enjoy and digest the eatables better. Similarly the advantages of mental exercise involved in the study of Mathematics are not apparent to an ordinary Indian student, and so, he reads Mathematics with great reluctance, not knowing that in proportion as he studies more of Mathematics, he will relish and master other subjects better.

"I have mentioned Mathematics," says Lock, 'as a way to settle in the mind a habit of reasoning closely and in train; not that I think it necessary that all men should be

deep Mathematicians, but that having got the reasoning which that study necessarily brings the mind to, they might be able to transfer it to other parts of knowledge as they shall have occasion."

There are men who are already physically strong, yet physical exercise will make them still stronger. Similarly there are men already intellectually very strong yet a study of Mathematics will most certainly add to their intellectual powers.

Rev. Dr. Chalmers has stated:—"I am not aware that as an expounder to the people of the lessons of the Gospel, I am much the better for knowing that the three angles of a triangle are together equal to two right angles: or that the square on the hypotenuse is equal to the squares of the two containing sides in a right-angled triangle. But I have a strong persuation that both the power to apprehend and the power to convince may be mightily strengthened—that the habit of clear and consecutive reasoning may be firmly established by the successive journeys which the mind is called on to perform along the pathway of Geometrical Demonstration. The truth is that as a preparative whether

for the bar or for the pulpit, I have more value in Mathematics for the exercise which the mind takes as it travels along the road, than for all the spoil which it gathers at the landing place."

The author of "The History and Philosophy of the Inductive Sciences" has shown in his "Thoughts on the study of Mathematics" that Mathematical studies judiciously pursued from one of the most effective means of developing and cultivating the reason: and that "the object of a *liberal education* is to develope the whole mental system of a man;—to make speculative inferences coincide with his practical convictions; to enable him to give a reason for the belief that is in him, and not to leave him in the condition of Soloman's sluggard: who is wiser in his own conceit than seven men who *can* render a reason."

To this may be subjoined the judgment of John Stuart Mill, which he has recorded in his invaluable system of Logic (Vol.) 11) in the following terms:—"The value of Mathematical instruction as a prepartion for the more difficult investigations (Physiology, society, government, etc.) consists in the

application of its method. Mathematics will ever remain the most perfect type of the Deductive Method in general; and the application of Mathematics to the branches of Physics furnishes the only school in which philosophers can learn the most difficult and important portion of their art, the employment of laws of the simpler phenomenon for explaining and predicting those of the more complex. These grounds are quite sufficient for deeming Mathematical training an indispensable basis of real scientific education and regarding with Plato, one who is *a y e w u e r p n r o s* as wanting in one of the most essential qualifications for the successful cultivation of the higher branches of philosophy."

The Study of Mathematics strengthens both the intellect and memory and tends to impart to us an assimilative memory rather than a sensuous one inasmuch as it teaches us to remember things by the aid of the intellect or thinking faculties; and discourages us from memorising a demonstration and the like by endless repetition. It gives us a memory which has brought immense wealth to Professor Loisette. The nature of

the subject admits of no such thing as cramming. We cannot cram Mathematics, whatever we learn of it must be got up intelligently.

It is true that Mathematics at first appears to be a very dry subject and most distasteful; but for that very reason we ought to study it with zest and zeal. In so doing, we shall be stronger in will-power. "Perhaps" says Huxley "the most valuable result of all education is the ability to apply yourself to the thing you have to do when it ought to be done *whether you like it or not.* It is the first lesson that ought to be learned, and however early a man's training begins, it is probably the last lesson that he learns thoroughly."

The abstruse nature of the subject compels a student to concentrate his attention. Mathematics is the best cure for mind-wandering. Bacon says—"If a man's wits wander, let him study Mathematics, for in demonstration if his wits be called away ever so little, he must begin again." Now, if on no other account, on account of this grand virtue which it inculcates, *viz.*, concentration of attention we ought to value Mathematics. No one who is

stricken with absent-mindedness can make his mark in any department of human activity.

The path to proficiency in Mathematics is so rough, and so hard an application is necessary that on the way we lose all our roughness and become perfectly smooth and frictionless, as it were, just as the wooden harrow used in this country becomes smooth by passing over the rough and uneven ground turned into clods by the plough.

Now a smooth ball or the like if put in rolling or sliding motion on the College floor will come to rest very long after a rough ball that was put in motion simultaneously with it. So brains that have lost a considerable amount of their friction by working in the rugged field of Mathematics and have now been smoothed down, so to speak, when once put in motion or set to some hard task will, other things being equal, stop or be tired out long after those brains that have not been similarly trained.

Not only does the study of Mathematics thus habituate us to steadfastness and perseverence but it engenders in us a strong inclination to work. It tends to make us bitter

opponents to inaction, it stores in us immense energy. The student of Mathematics being compelled to work very hard and long for the sake of success in his subject, goes on working hard even after this impressed force is withdrawn, being then impelled by the energy accumulated in him just as a railway train continues travelling for a long time even after the steam is shut off. But alas! for the rash youths who no sooner are set free from the great motive power—Mathematics or some other branch of learning—and enter life, than they come to a dead stop on account of the brake of sensual indulgence; or at least get their motion considerably retarded by that brake.

Mathematics, startling as it may sound, aids Religion in a most remarkable manner and strengthens the foundation of moral character. Every now and then it puts us in a most humiliating mood, it makes us realize our own incapability, it repeatedly brings us face to face with something which we think we cannot surmount. It makes us humble and meek. It tends to do away with our vanity and self-conceit. It breaks us down and consequently exercises the will of God

on us. "Do you," says Theodore, Monod, a French Divine, "know what is God's chief difficulty with us? It is not the making us, it is the breaking us. It is not the edifying us it is the putting us down. And therefore it is that God's chief instrument for edification is the pick-axe. He must break us down, down, down, and whatever He gives us to do for His service. He will first of all show us that we are not able to do it. O God, take me, break me, and make me." The value of Mathematics in this respect is well pointed out in the following remark by Locke:—"A man in the study of Mathematics will see, that however good he may think his understanding yet in many things and those very visible, it may fail him. This would take off that presumption that most men have of themselves in this part, and they would not be apt to think their minds wanted no help to enlarge them, but there could be nothing added to the acuteness and penetration of their understanding." All this shows that the sharp discipline to which it subjects a man has a wonderful influence in smoothing down his asperities in accustoming him, as a rule, to the habits of patience, perseverance, self-

denial and humility."

"True science," says Huxley, (including Mathematics undoubtedly), "and true religion are twin sisters, and the separation of either from the other is sure to prove the death of both. Science prospers exactly in proportion as it is religious, and religion flourishes in exact proportion to the scientific depth and firmness of its basis. The great deeds of philosophers have been less the fruit of their intellect than of the direction of that intellect .....by an eminently religious tone of mind. Truth has yielded rather to their *patience*, their *love*, their *single heartedness* and their self-denial than to their logical acumen."

Issac Todhunter in his Essays on Education says that of all the subjects required for passing University Examinations, Mathematics furnishes the most reliable test of a man's working powers. A student may do remarkably well in the Examination in a language; and yet this may have been owing to his keeping constant company with a man who always speaks that language and is a thorough master of it. A student may distinguish himself in History in some Examination, and yet this may largely be due to

his *passively* hearing other students while they were preparing that subject for their Examination. A man may obtain very high marks in a Practical Science Examination; and yet this may be on account of his having familiarized himself with the Science Apparatus and its use for *amusement's* sake. And so with the other subjects. But a man who excels in Mathematics could not have done so, except by dint of hard labour. He proves himself capable of facing difficulties and doing his duty well, however disagreeable that duty may be.

Nothing particular has as yet been said about "problems" as against "book work" in Mathematics. They are hard nuts to crack for the student. But once cracked they yield an ambrosial kernel; and the student thus derives an exquisite pleasure from the sweets of intellectual conquest. No other branch of knowledge can present a like phenomenon. After a hard problem has been solved, you will often observe the Mathematician's eye brighten, and at length, with a pleasure (of which the ecstacy of Archimedes was but a simple expression) hear him explain, "I have got it, I have got it."

It may not be out of place to say something as to how charming and fascinating this subject has been to some persons or to what extent people of yore have been impressed by its importance. *Plato* loved it to such a degree that the inscription over the entrance to his school ran—"Let none ignorant of Geometry enter my door," and on one occasion an applicant who knew no Geometry is said to have been refused admission. It is related of a Mathematician that while he was absorbed in solving some problem, the besieged city in which his house lay was taken by the enemy, and to the spot where he sat musing, came up with a drawn sword in hand, a soldier who was about to break the slate of his life. The Mathematician who had been quite ignorant of the capture of the city, did not even now, lift up his head and look at the soldier. The astonished soldier shouted at the top of his voice to make the poor victim prepare for death. At this the Mathematician raised his eyes and said: "Wait a moment; I am about to solve it" (the problem). The citywas captured by the enemy, but his heart had been captivated by Mathematics.

Sir Isaac Newton, oftentimes, when busy at some Mathematical theorem used to forget taking his meals. I may add two amusing anecdotes—(1) Newton invited a friend to dinner and forgot it. The friend arrived and found the philosopher in a fit of abstraction. Dinner was brought up for one. The friend, without disturbing Newton, sat down and despatched it. Newton, recovering from his reverie looked at the empty dishes and said: "Really if it wasn't for the proof of the contrary before my eyes I could have sworn I had not yet dined." (2) Once when riding home from Grantham he dismounted to lead his horse up a steep hill, when he turned at the top to remount he found that he had the bridle in his hand while his horse had slipped it and gone away.

Galileo had very long been purposely kept in ignorance of Mathematics but one day, by chance hearing a lecture on Geometry, he was so fascinated by the Science that he thence forward devoted all his spare time to this study, and finally he got leave to discontinue his former studies. He preserved his enthusiasm for the subject in spite of poverty, public ridicule, and persecution.

And so did *Kepler* notwithstanding domestic troubles, poverty and other inconveniences.

Archimedes could not disengage himself from Mathematical dreams even when walking or when bathing as is evidenced by the well-known story which says that *Archimedes* one day while taking his bath was so much elated at the discovery he then made that unable to contain himself he immediately ran almost naked into the street crying Eureka, Eureka "I have found it, I have found it."

It is related of *Eulier* that even in the perusal of Virgil's poetry he met with images that would recall the associations of his more familiar studies, and lead him back from the fairy scenes of fiction to the element more congenial to his nature, of Mathematical abstraction.

Amongst the ancient Hindus, Mathematics was so extensively loved that even their females were well versed in the subject.

Amongst the rich, Mathematics has exercised its sway over Boyle, Cavendish,

Napier, Lord Kelvin. and others. Amongst men of letters Milton, Bacon, Locke, Carlyle Helps, Froude.....and many others may be counted amongst its fervent admirers, if not votaries.

Perhaps some of you can still see no connection between abstract and practical science, and hold the former in little esteem, despising mental discipline unless you perceive its direct reference to the actual business of life, and so reject Mathematics as of little practical interest, calling it with Alexander Pope as—

"Tricks to show the stretch of human brain,
Mere curious pleasure or ingenious pain."

Remember, Gentlemen, immediate usefulness alone is a fallacious recommendation for a branch of learning. Don't shun Pure Mathematics on the ground of its *purely speculative character*. "That sound judgment", says Professor De Morgan in his remarkable introduction to the London edition of Ram Chandra's Maxima and Minima—"that sound judgment which gives men well to know what is best for them as well as that faculty of *invention* which leads to development of resources and to the increase of wealth and

comfort, are both materially advanced, perhaps cannot rapidly be advanced, without a great taste for *pure speculation* among the general mass of the people, down to the lowest of those who can read and write ....." After giving a most satisfactory proof of the above statement the above-mentioned writer puts the conclusion in the following words :—

"The History of England as well as of other countries has impressed me with a strong conviction that pure speculation is a powerful instrument in the progress of a nation." Plato advised the Athenians to betake themselves to the study of Mathematics, in order to evade the pestilence incident to the international war which was raging in Greece."

Mathematics is knowledge and consequently it is power. It is a *weapon*, though a very heavy one. If we cannot wield that weapon, the fault is all our own ; because we *could* wield it if we *would*, by dint of patience and perseverance ; and once wielded, that weapon is something awful in our hands. Knowledge of Mathematics is like an estate which should be watered and cultivated

laboriously before it yields abundant crops. Many men have reaped rich harvests out of this apparently barren land.

The *processes* of the Differential Calculus seem far remote from the Propositions of Physical Science, yet Newton was led by their aid to found a system of Mechanics equally suited to determine the motion of the stone falling to the ground, or the revolutions of the Planetary bodies. *Conics* is a branch of pure Mathematics dealing with the sections of a cone. It could hardly be imagined as susceptible of any useful or interesting application whatever. But *Kepler* came and he applied it to the motions of heavenly bodies, thus clearing up most intricate difficulties in Astronomy. Moreover the same Conic Section was found to apply to the motion of anything whatever projected here on our own planet; be it a cricket ball, an arrow or a bullet, even our own bodies in the act of jumping. The process of finding the H. C. F. of any two numbers in Algebra has been made use of by Sturm in solving with great ease Equations of any degree whatever. The *Theory of Quadratic Equations* was made use of by our own countryman, Master Ram

Chandra of Delhi, in working out problems of great practical interest in Maxima and Minima. In Trigonometry and Algebra we meet with what are called *Exponential Functions* and *Imaginary* or *Impossible Quantities.* When you first study them, I suppose you will be inclined to say "Of what use in the real world are *Imaginary* quantities, why should we waste our time on *Impossibilities*?" My friends, let me inform you that what you will thus cast off with disdain, has lately been made the corner stone of a new mansion in the world of Science, being developed into Hyperbolic Functions. The symbols e and π, (meaningless to the unthinking student,) represent numbers which enter into analysis from whatever side Science and Art are approached. An anecdote might be quoted for illustration. De Morgan was explaining to an actuary what was the chance that at the end of a given time a certain proportion of some group of people would be alive: and quoted the actuarial formula involving π, which he explained stood for the ratio of the circumference of a circle to its diameter. His acquaintance, who had so far listened with interest, interrupted him and exclaimed,

"My dear friend, that must be a delusion; what can a circle have to do with the number of people alive at the end of a given time?" Don't be surprised to know that Ball writes of a distinguished Professor remarking that "it is impossible to conceive of a universe in which e and π should not exist."

I sympathise with those of you to whom the abstract principles involved in Mathematics appear to have scarcely any use or aim; but if you continue your inquiries, your mature judgment will *rectify* your first opinion and at length you will find yourselves possessed of, to use the words of Professor Hall, "an instrument of matchless power and of universal application; a language which nature must hear, and to which she shall always reply."

Even if the study of Mathematics bear no fruit at all, do not regard your labour spent on it as wasted. Nothing is wasted or lost in nature, matter is indestructible and cannot be lost, energy is indestructible and cannot be lost; and so I maintain labour is indestructible and cannot be lost. Rivers take away with them a great deal of earth and other substances from the plains, and so far

as we can see the earth carried away is lost, but the same earth collects in the sea; and in course of time forms islands there. The Sun dries up in the summer tanks, pools and lakes, and we think the water is lost; but before autumn is ushered in, the same water comes down again in the form of rains. Similarly kinetic energy is converted into potential energy, thermal energy, electric or any other form of energy, but it is never lost, although it may so appear to us. Just in the same way, rest assured, labour is never lost; it is sometimes changed into experience, at other times it becomes, as it were, stored up for future use; but it is never lost. The labour of Columbus, although it did not bring forth the desired result, was far from being lost; the attempts of Englishmen at finding the North-West passage to India although apparently fruitless, caused the Arctic Ocean to be explored. Similarly attempts at finding the philosopher's stone led to the discovery of the Science of Chemistry. Again attempts at unreal Astrology led to real Astronomy. So, the apparently bootless endeavours of geometricians at the duplication of a cube, the trisection of an angle, and the squaring

of a circle, were the cause of Conic Sections being discovered. The vain struggles and efforts to construct a perpetual motion machine advanced most considerably the Science of Dynamics. The celebrated John Hunter occupied a great deal of his time in studying most carefully the growth of a deer's horn (a sheer waste of time and energy in the opinion of most of us); but this apparently useless knowledge well applied in the case of a dying patient was one of the causes which rendered his name immortal. His labour was not lost and so will not your labour be lost which you devote to the study of Mathematics, but will reproduce itself in other forms of fruitful energy. It is rather sacrilegious to think of lost labour in connection with a subject of which in the words of no less an authority than Helmholtz, we may say. "Of all branches of human knowledge, there is none which, like it, has sprung as a completely armed Minerva from the head of Jupiter; none before whose death-dealing Aegis doubt and inconsistency have so little dared to raise their eyes!"

The vibrations of a lamp suspended from the ceiling taught Galileo how to construct

the first pendulum-clock; a falling apple gave Newton a lesson on the mysteries of the solar system; a boiling kettle instructed George Stephenson how to make the steam engine; a frog's leg twitching when placed in contact with different metals directed Galvani to come to the important results wherein lay the germ of the Electric Telegraph. If apparently insignificant objects could teach such important lessons, will not Mathematics (which means *Knowledge* and *Science* itself) be able to teach you a great deal?

Only a third eye is wanted (an eye in the head or brain, Mahadeva's third eye) to discover the *Parvati* of joy and glory on the mountains of Mathematics. Oh! for the keen penetrating eye to which—

"There are tongues in trees, books in the running brooks,
Sermons in stones and good in everything."

We are reaping abundantly the fruits of the labours of others. We travel by rail, the most desirable kind of conveyance; we get our errands run by electricity harnessed for our sake, we live in comfortable houses, wear the clothes cut and sewn to suit our convenience, get our food cooked and prepared

in such a way as to keep us in good health and many other things we enjoy which have been thought out and worked out for us by others. Let us not forget that we also ought to do something for others in return. We owe a heavy debt to humanity. Let us try to leave the world better than we found it. Let us try to leave some foot-prints on the sands of time. Let us try to dive deep into the Ocean of Science and Mathematics and bring out, if possible, some pearls which may adorn the world.

Then work, work, work with all your heart, with all your might, remembering that work is worship and remembering also that work is life.—

"We live in deeds, not days;
in thoughts, not breaths;
in feelings, not in figures
on a dial,
He lives most who thinks most,
feels the noblest acts the best."

Genuine work will be found to be its own reward. Work is the normal state of man.