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THE

SCHOOL MAGAZINE.

NOVEMBER, 1881.

UNITS.

Condensed from a Paper read before the Wentworth Teachers' Association, by the President, W. H. BALLARD, M. A.

PROFESSOR Proctor, the astronomer, begins one of his admirable Essays in "Light Science for Leisure Hours" in this way :—

"A distinguished French astronomer remarks, that a man would be looked upon as a maniac who should speak of the influence of Jupiter's moons on the cotton trade, yet as he proceeds to show, there is an easily traced connection between the ideas that at first sight appear so incongruous. The link is found in the determination of celestial longitude..

"Similarly," Mr. Proctor goes on to say, "what would be thought of an astronomer who, regarding thoughtfully the stately motion of the sidereal system as exhibited on a magnified and therefore appreciable scale by a powerful telescope, should speak of the connection between this movement and the intrinsic worth of a sovereign? The natural thought with most men would be that too much learning had made the astronomer mad. Yet when we come to inquire closely into the question of a sovereign's intrinsic value we find ourselves led to the diurnal motions of the stars, and that by no very intricate path. For what is a sovereign? A coin containing so many grains of gold mixed with so many grains of alloy. A grain we know is the weight of such and such a volume of a standard substance, that is, so many cubic inches or parts of a cubic inch of that substance. But what is a cubic inch? It is determined we find as a certain fraction of the length of a pendulum vibrating seconds in the latitude of London. A second we know is a certain portion of a mean solar day, and is practically determined by what is called a sidereal day, the interval namely between the successive passages of the same star over the celestial meridian of any fixed place, that is the time in which the earth makes one complete revolution on its axis. This interval is assumed to be constant, and it has indeed been described as the one constant element known to astronomers.

We find then that there is a connection, and a very important connection, between the motions of the stars and our measures, not merely of value but of weight, length, volume and time. In fact our whole system of weights and measures is founded on the apparent diurnal motion of the sidereal system, that is on the real diurnal rotation of the earth." The unit of time, then, is the foundation on which the English or Imperial system of weights and measures is constructed. This is the system adopted, with some modifications of minor importance, by all English-speaking people. It is necessary therefore for us to ascertain accurately what constitutes this unit, and to give heed to some of the circumstances more intimately associated with it. The unit of time is a day. This seems sufficiently accurate and definite until we come to ask ourselves what is a *day?* This is commonly said to be the time in which the earth makes one complete revolution on its axis, and this is true enough for one sort of day, namely, the sidereal day, which is the time which elapses between the successive transits of the same fixed star over the meridian of any place as already mentioned, and which being an invariable quantity would have served as an admirable unit for the measurement of time. But the transit of a star over the meridian of any place was not a phenomenon sufficiently striking to be generally or readily observed, and as the complete alternation of light and darkness could escape the observation of no one, this period has been fixed upon as the most convenient unit to which to refer other periods of time for measurement. And just here let me say a word or two as to the meaning and accurate use of the words *unit* and *measure.* If we wish to estimate a given magnitude, such as a length, a weight, a sum of money, &c., we must take some well defined magnitude of the same kind which we call the *unit*, and the number of times this unit has to be repeated in order to make up the given magnitude is called the *measure* of that given magnitude. The measure of a magnitude is therefore the quotient obtained by dividing a quantity by its unit, or as it is sometimes expressed, by dividing one concrete number by another concrete number of the same denomination. The measure of a magnitude is thus an *abstract* number. Again, since the measure of a quantity is the number of times that quantity contains its unit it is evident that this measure will be different for different units, although the quantity itself may remain the same. Thus, suppose we wish to ascertain the length between two objects, we first fix upon a definite length as the unit—a foot, say—and we find that the required length contains this unit 12 times; we then say the measure of the required length is 12, But suppose we had fixed upon a much smaller unit—say an inch—we should then have found that the required length contains the unit 144 times, and therefore its measure would be 144, &c. We thus find that the measure of a quantity varies inversely as the unit of measurement.

The unit fixed upon for the measurement of time is the solar day, that is the time which elapses between two successive transits of the sun across the meridian of any place. This would seem to be a sufficiently well defined unit, for the time when the sun crosses the meridian can be observed within a fraction of a second, and the time which elapses until he again crosses this same meridian can be accurately measured. Unfortunately this length of time is not a constant quantity, but as will appear presently, is continually changing from day to day throughout the year. In consequence of this irregularity in the length of the solar day the unit of time is defined to be the *mean solar day*, that is the mean or average of all the solar days which elapse during one complete revolution of the earth round the sun.

The want of uniformity in the length of the solar day is owing to two causes:

1. The earth's variable motion in its orbit round the sun.

2. The inclination of the earth's axis to the plane of its orbit.

The cause of the earth's variable motion and its effect on the length of the solar day may be readily explained. The earth's path round the sun, we know, is not a circle but an oval or ellipse. Nor is the sun placed in the centre of this ellipse, but nearer to one end and in the line of the longest diameter of the oval. Now, suppose the earth to be situated in that part of its orbit farthest from the sun, so that every instant of its motion thereafter brings it nearer and nearer, or as we may express it, the earth is now falling towards the sun, and we know that all falling bodies increase in speed the farther they fall, so that the velocity of the earth increases continually until it reaches its point of greatest proximity to the sun. The ratio of its greatest to its least velocity is rather greater than that of 16 to 15, that is the greatest velocity exceeds the least by more than one-fifteenth. It so happens that the earth's greater velocity and also its greater proximity to the sun combine to increase the length of the solar day during the winter months. [The diagram by which this was explained unfortunately cannot be given.]

To explain the other cause of the variation in the length of the true solar day, namely, that depending on the inclination of the earth's axis to the plane of its orbit, would occupy too much of our time at present. It will be sufficient to state that the inclination of the axis gives rise to much greater irregularity than the earth's variable motion in her orbit, the latter making the true solar day too long for about one-half the year and too short during the other half, whereas the former makes the day too short from the beginning of February to the beginning of May, and from the beginning of August to the beginning of November, and too long during the other two periods of three months each. These two causes combined give rise to the following results.—The sun crosses the meridian at 12 o'clock only four times during the year, and then not at regular intervals of three months, but on April 16, June 16, Sept. 1, and Dec. 25. The sun is slow, that is crosses the meridian after 12 o'clock from Christmas day until the middle of April, being farthest behind on the 11th Feb., when he is nearly a quarter of an hour slow. During the next two months he is too fast, and is on the meridian therefore before 12 o'clock. The greatest error during this period is not quite 4 minutes, and occurs on May 14. The sun is slow again throughout the summer months, being 6¼ minutes behind on the 16th July. From the 1st of Sept. almost to the end of the year the sun is too fast, and reaches its maximum error near the beginning of November (Nov. 3), when it is noon by the sun 16⅓ minutes before it is noon by the clock. It may be noticed here that during the winter months, when all the causes which have been indicated combine to lengthen out the solar day the sun loses time most rapidly, the actual loss from the 3rd of Nov. until the 11th Feb.. a little over three months, being more than half-an hour.

Hence we see clearly the necessity for taking not any particular solar day, but the mean or average of all the solar days throughout the year, in order to obtain a reliable standard for the measurement of time. Having thus fixed upon the unit or standard, other divisions of time, as hour, minute, &c., must be defined, with reference to this unit, thus, an hour is properly defined as the twenty-fourth part of a day, and not as sixty minutes, and so on. The unit of time being thus defined, the next step in the Imperial system of weights and measures is the establishment of a unit for the measurement of length. This is made to depend upon the unit of time by an Act of Parliament passed in the fifth year of the reign of George IV., which enacts that if a pendulum which will vibrate seconds in London on a level of the sea, in a vacuum, be taken and all the part thereof that lies between the axis of suspension and the centre of oscillation be divided into 39·1393 equal parts, then will 10,000 of these parts be an imperial inch, 12 whereof make a foot and 36 whereof make a yard. It was also enacted that the brass standard yard then in the custody of the Clerk of the House of Commons, should be the Imperial standard yard, and that this Imperial standard yard should be the *unit* or only standard measure of extension wherefrom or whereby all other measures of extension whatsoever, whether the same be linear, superficial or solid, shall be divided, computed and ascertained, and that the thirty-sixth part of this yard shall be an inch.

It was supposed that by means of the pendulum a new standard yard could be at any time constructed, but when the old standard was rendered useless by the burning down of the Houses of Parliament in 1834 and its restoration rendered necessary, so much doubt was entertained by men of science as to how far the standard could be accurately restored by means of the pendulum, that the present standard was actually constructed from a comparison of copies that had been carefully made of the old standard. This is a solid bar of bronze 38 inches long and one inch square; near each end a small cylindrical hole is sunk in which is inserted a gold plug dressed down even with the bar, and the distance between the centres of these gold plugs, when the bronze is at a temperature of 62° F., is the Imperial standard yard.—18 and 19 V. c. 72.

Some of the difficulties that would require to be met in constructing a standard by means of the pendulum will be rendered apparent by an examination into the conditions which are required by the Act to be observed, and which of course are necessary for a scientific determination of the one unit from the other. In the first place the experiment must be made in air the buoyancy of which lessens the weight of the pendulum. This buoyancy is known to be different at different times, and careful allowance must be made for it. It is therefore necessary to settle upon that condition of the atmosphere in which the pendulum is to be swung, and accordingly it is enacted that the vibrations shall be such as would be produced by a pendulum if swung in a vacuum.

Again, in consequence of the earth's revolution on its axis every substance on its surface has a tendency to fly off, and this centrifugal tendency contributes somewhat to modify the effect of the attraction of gravitation. It is easy to see that this tendency to fly off is greatest at the equator, and consequently that bodies situated nearer the equator will be less affected by the earth's attraction than those further North or South of it. This centrifugal tendency is sufficient to counteract 1-289 of the force of the earth's attraction at the equator and were the earth to make a revolution on its axis in an hour and a half instead of in 24, substances at the equator would have no weight at all. There is another circumstance which causes a variation in the earth's attractive force for different latitudes, namely, the difference between the equatorial and the polar diameter. In consequence of the earth's surface being farther from the centre at the equator than at the poles the force of attraction will be greatest at the poles and diminish towards the equator. The effect of these two causes combined is that the attractive force of the equator is about 1-194 less than it would otherwise be. The effect of this variation in the earth's attraction is readily perceptible in the vibrations of the pendulum, the increased attraction causing it to vibrate more rapidly, so that a clock regulated to keep correct time at any place will lose time if taken towards the equator; and gain if carried further from it. A clock for instance, that keeps correct time at London would lose 12 seconds a day in Paris, and at the equator would lose nearly 2¼ minutes. From these considerations we see the force of the requirement that the pendulum shall be such as shall vibrate seconds in the *latitude of London.*

Thirdly, we know that the earth's attractive force is different for different distances above or below its surface, and that in consequence of this it would be necessary to restrict the pendulum to some particular altitude, and so the level of the sea is selected as the most appropriate. It is very clear then that to determine the unit of length by means of so delicate an instrument as the pendulum it is necessary that it should beat seconds of *mean time*—not sidereal or solar time—in a *vacuum*, in the *latitude* of London and at the *level* of the sea.

The next step in the development of the system brings us to the unit of weight:—this is now the pound Avoirdupois. In the Office of the Exchequer at Westminster there is deposited a cylinder of platinum (marked P. S. 1844, 1 lb.) and this weight is the Imperial standard pound Avoirdupois, and is the only standard measure of weight from which all other weights and measures having reference to weights are derived, and one equal seven-thousandth part of such pound Avoirdupois is a grain, and 5760 such grains is a pound Troy (18 and 19 V. c. 72, s. 3). This unit is connected with the unit of length by the same Statute that derived the unit of length from that of time, wherein it is declared that a cubic inch of distilled water, weighed in air, by brass weights, at 62° F. the barometer being at 30 inches, is equal to 252.458 grains, and that 7,000 such grains are a pound Avoirdupois, and 5,760 grains a pound Troy. It was supposed that by this means a new standard could be constructed should the old one be lost or destroyed, but when the old standards —there was a standard Troy pound as well, up to this time—were lost by the burning down of the Houses of Parliament, the Commissioners did not restore them by pursuing the above method, but as in the case of the standard yard, constructed the present standard by a comparison of copies that had been carefully made of the former one.

Let us now examine into the conditions under which this cubic inch of distilled water has to be weighed before it will furnish us with a sufficiently reliable standard.

Firstly, then, why limit it to being weighed in air? For the simple reason that every substance on being weighed in air weighs less than its true weight by the weight of the quantity of air displaced, which is considerable, enough to make a perceptible difference in weighing even so small a volume as a cubic inch. The weight of the air which would occupy one cubic inch of space is about one-third of a grain, not a very great weight absolutely, but a weight of great importance comparatively when we bear in mind that the chemical balance is so finely constructed as to detect a difference in weight so small as the one-thousandth part of a grain. As an illustration of the weight of the atmosphere I may say that the air in this room weighs 1,340 lbs.

Secondly, what has the height of the barometer to do with it? When the barometer stands high we know the air is heavier, meaning by this that a greater mass of air is crowded into the space of a cubic inch, and consequently one cubic inch of water displaces a greater weight of air when the barometer is high than when it is low, that is, the apparent weight of this cubic inch of water grows less the higher the barometer rises. Let us examine now whether a small change in the barometric reading would make an appreciable difference in the weight of a cubic inch of air, weighing at best only one-third of a grain. For this purpose suppose the barometer to fall from 30 in. to 29 in., that is the air becomes 1/30 lighter, or its buoyancy is diminished by 1/30, that is, this cubic inch of air becomes lighter by 1/90 of a grain, and consequently the apparent weight of a cubic inch of water is heavier by that much. Knowing also how small a difference in weight can be detected by a well made balance we can readily understand that a difference of even a small fraction of an inch in the barometric reading will make an appreciable difference in the weight of a cubic inch of water. The next condition to be observed is that the thermometer is to stand at 62° F. We know that most substances increase in volume when heated and contract again when the heat has been withdrawn, and, for certain temperatures, water forms no exception to this rule. If, then, the weighing were done with the thermometer below 62°, the water would be more dense, more of it would be required to fill a cubic inch of space and consequently the cubic inch of water would weigh heavier than it would at 62° and conversely for temperatures higher than 62°.

Lastly, why should brass weights be used?

If the weight of the substance which is being weighed in one scale-pan of the balance is affected by the temperature and pressure of the atmosphere, so also must the weights in the other scale-pan. Now, any given weight of brass which is about 8 times as heavy as water, will occupy nearly 3 times as much space as the same weight of platinum which is more than 21 times as heavy. Suppose then, an ounce of brass and the same weight of platinum to be accurately balanced in a vacuum, would they balance if surrounded by air? Certainly not, for the brass weight of which we are speaking occupying 3 times as much space as the platinum one will be affected 3 times as much by the bouyancy of the air, that is, will have its weight diminished to 3 times as great an extent as the oz. of platinum, and consequently the brass weight will no longer be able to balance the other, so that although the cubic inch of water of which we are speaking would weigh the same in a vacuum whether the weights used were brass, platinum or any other substance, yet this would not be true when the weighing is done in air, for we have seen that a substance that would balance a certain absolute weight of brass in air would not be heavy enough to balance the same absolute weight of gold, platinum or any substance heavier than brass. It follows therefore, that variations in the atmospheric pressure will affect the apparent weight of light substances to a greater extent than heavier ones, and hence the necessity for selecting some specified substance with which to do the weighing.

We are thus forced to the conclusion that the prescribed conditions were all necessary in determining with requisite accuracy the unit of weight from the unit of length, nor are we surprised that this method was not adopted to produce a new standard so long as any other means of doing so was available.

The unit of capacity is the space occupied by 10 lbs. Avoirdupois of distilled water weighed in air, the temperature being 62° F. and the barometer at 30 in. This unit is called the *Imperial* gallon. It is easy to find the number of cubic inches in a gallon, for if 252.458 grs. of water occupy one cub. inch it follows that 10 lbs. or 70,000 grs. must occupy 277.274 cubic inches. This space might, therefore, have been fixed upon as the unit of capacity, and the necessity for any reference to the density or temperature avoided, that is, the unit might better have been defined by direct reference to the unit of length—as is done in the metric system—and not indirectly through the unit of weight. I may notice here that the unit of capacity is not the unit of volume, the *unit of volume* being a cubic yard. The unit of surface is a *square yard.* I have only one more unit to mention in connection with the Imperial system of weights and measures, this is the unit of money, the pound which is the value of the coin called the sovereign. This coin is made of standard gold which is composed of 11 parts by weight of pure gold to 1 part alloy. 40 lbs. Troy of this standard metal are coined into 1869 sovereigns, so that the sovereign contains a little over 123¼ (.274) grains of standard gold. The assertion that there is a very intimate connection between the motions of the heavenly bodies and the intrinsic value of a sovereign is thus fully borne out. I had intended to consider the units of *velocity*, *force*, *momentum*, *work* and some others, but I pass them over for the purpose of directing your attention briefly to the Metric or Modern French system of weights and measures.

The first suggestion of a change in the previous system dates back some hundreds of years, but until near the close of the last century no important progress towards this object had been made. In 1790 the French government made proposals to the British that an equal number of members from the Academy of Sciences and the Royal Society of London should meet in order to determine the length of the simple pendulum vibrating seconds in latitude 45° at the sea level, with a view to making this the unit of a new system of measures. This proposal, however, was unfavorably received, but the French government having undertaken the scheme was determined to carry it through and accordingly secured the appointment of a commission by the Academy of Sciences, and three units were submitted to them, namely, the length of the pendulum, the fourth part of the equator and the fourth part of the meridian. The commissioners decided on the last of these as the one best suited to their purpose, resolving that the quadrant of the meridian lying between the equator and the pole, measured as along the surface of still water should be divided into ten million equal parts, and that one of these equal parts should be taken as the basis of the new system, and should be called a 'metre.' The measurement of that part of the meridian lying between Dunkirk and Barcelona was immediately undertaken and the result communicated to a committee of 20 members, 9 of whom were French, the others being deputed by the governments of Holland, Denmark, Spain and other European States. By this commission the length of the metre was found to be 443.29 Parisian lines, equivalent to 39.37 English inches, and a standard of it, being a rod of platinum, constructed and deposited among the French archives. The Metric system is a decimal system throughout, the subdivisions of the metre being tenths, hundredths and thousandths of the metre, and measures greater than the metre are either 10 or some power of 10 times the metre.

The unit of length being thus fixed upon, the units of weight and volume are made to depend upon it the same as in the English system but with some modifications of the conditions under which these units are derived. Thus the unit of weight is the weight of a cubic centimetre of distilled water at a temperature of 4° C., or about 39° F., if weighed in a vacuum. This temperature is taken because water is then heaviest or has its maximum density. The name given to this unit is the *gramme.* It will be noticed that in specifying this unit no mention is made of the pressure of the atmosphere, this being rendered unnecessary by requiring the weight in a vacuum. On account of the smallness of the gramme the legal standard has been constructed to weigh a kilogramme or 1000 grammes (= $2\frac{1}{5}$ lbs. about,) and is a cylinder of platinum whose height is equal to its diameter and is therefore about $1\frac{1}{2}$ in. high. The unit of area is a square metre, and of capacity is the capacity of a cubic decimetre (or something less than our quart) which is thus defined with direct reference to the unit of length. A mixture of 9 parts of pure silver and 1 part copper weighing 5 grammes is selected as the unit of money, and is called the *Franc.*

The units of *velocity*, *force*, *work*, &c. in this system, differ as much from the same units in the English system as do those which we have already considered, and an investigation of them would be interesting and may possibly serve as the subject of a paper at some future meeting of this Association.

The use of the Metric system is continually being extended. It was rendered legal in England in 1864, the weight of a kilogramme being declared equal to 15432.3487 grs. It has the advantage of being the only system scientifically constructed, and is destined, no doubt, sooner or later to supersede other systems, as the decimal system of estimating money has already done in many cases. As one of the benefits to result from its adoption, and one too which concerns us all here very intimately, I may add that it has been estimated that the assimilation of our system of weights and measures to that of numeration and notation would reduce by one-half, the time required in our public schools to teach the elements of Arithmetic.

ENGLISH DEPARTMENT.

COWPER.

Sketch of his life.—William Cowper was born in Hertfordshire, England, on the 26th of November, 1731. His parents were related to some of the most aristocratic families in England, so that we are told that "the highest blood in the realm flowed in the veins of the modest and unassuming Cowper." On the death of his mother, which occurred when he was only six year old, he was sent to a school a few miles distant from his father's residence. His experience here was so unhappy that it seems probable that he formed here those unfavorable opinions of public schools which are to be met with in his *Tirocinium.* He completed his academical studies at Westminster without acquiring, according to the best authorities, a reputation for very varied or extensive learning. Cowper was next sent to London to engage in the study of the Law—a pursuit, as may readily be imagined, little suited to the disposition of the future poet. At the termination of his nominal apprenticeship he took chambers in the Temple, where he resided about twelve years. Here he lived as a man of the world, though free from its grosser vices, and became acquainted with several of the eminent literary men of the day. He was nearly all his lifetime subject to fits of melancholy, during which he seems to have neglected his favorite literary pursuits

The greater portion of his fortune being at length spent, he solicited a place from a relation in the government of the day, who duly nominated him to the position of Clerk to the Journals of the House of Lords. His friend's right of nomination was challenged and it became necessary for Cowper to prepare for a public examination in the House in order to demonstrate his fitness for the position. The sensitive nature of Cowper shrank from the test, and in a fit of dejection he attempted to commit suicide in order to escape it. It was of course an impossibility for him to retain office after this occurrence, and he was for some time in a deplorable state of mind, and his melancholy assumed the form of a religious monomania, in which his most prominent idea was that he had committed the unpardonable sin.

He renounced London for ever, and at first resided at St. Albans where some improvement in his mental condition took place. He left this place for Huntingdon where he became acquainted with the Unwins with whom he ever afterwards lived. He resided next for nineteen years at Olney and lastly at Weston where he died · the 25th of April, in the year 1800. Towards the close of his life the Government settled upon him an annual pension of £300 as a reward for his literary services. The last years of his life were years of gloom. Chief among the friends who at various periods sought to soothe the unfortunate poet in his sad affliction were not only the Unwins but also the Rev. John Newton of Olney, Lady Austen, and his cousin Lady Hesketh.

His Works.—Cowper did not come before the world as an author till he had completed his fiftieth year. In little more than a quarter of a year from the time that he began he had finished the poems entitled *Table Talk*, *The Progress of Error*, *Truth*, *Expostulation*. To his acquaintance with Lady Austen, who related to him the story, the world is indebted for the ballad of *John Gilpin*, and also for the idea of *The Task*. Fearing that *The Task* would not make a sufficiently large volume for the booksellers he added to it his poem *Tirocinium* or a Review of Schools. A few weeks after finishing *The Task* he began in 1784 his translation of Homer's Iliad and Odyssey. He next undertook to edit a new edition of Milton's works but he never enjoyed sufficient composure of mind to carry out this undertaking. He is also known as the author of many popular hymns which strengthen in no small degree his claim to be considered as the Christian Poet.

The Task.—In the preface to *The Task*, Cowper gives its history as follows:—"A lady fond of blank verse demanded a poem of that kind from the author, and gave him the Sofa for a subject. He obeyed; and having much leisure, connected another subject with it, and pursuing the train of thought to which his situation and turn of mind led him, brought forth at length, instead of the trifle which he at first intended, a serious affair—a volume."

In a letter to Mr. Unwin, in 1784, Cowper explains at some length the object he had in view while writing *The Task*.

"What there is of a religious cast, I have thrown towards the end for two reasons; first, that I might not revolt the reader at his entrance, and secondly, that my best impressions might be made last. Were I to write as many poems as Lope de Vega or Voltaire, not one of them would be without this tincture. If the world like it not, so much the worse for them. I make all the concessions I can that I may please them, but I will not please them at the expense of conscience. My descriptions are all from nature; not one of them second-handed. My delineations of the heart are from my own experience; not one of them borrowed from books, or in the least degree conjectural. In my numbers, which I varied as much as I could, I have imitated nobody, though sometimes perhaps there may be an apparent resemblance, because at the same time that I would not imitate, I have not affectedly differed. If the work cannot boast a regular plan (in which respect, however, I do not think it altogether indefensible), it may yet boast that the reflections are naturally suggested by the preceding passage, and that except the fifth book, which is rather of a political aspect, the whole has one tendency—to discountenance the modern tendency after a London life, and to recommend rural ease and leisure as friendly to the cause of piety and virtue."

From the foregoing it will be apparent that *The Task* is a didactic poem—moral, satirical and descriptive—with no regular plan, and treating of a vast variety of subjects. "The best didactic poems when compared with *The Task* are like formal gardens in comparison with woodland scenery." It is divided into six books entitled respectively, The Sofa, The Time-piece, The Garden, The Winter Evening, The Winter Morning Walk, The Winter Walk at Noon,—these titles being slight indications of the topics treated of in their corresponding books.

His contemporaries.—These were the members of the Romantic or National School of English Literature who wrote before 1800. They can be readily found in any work on English literature.

Criticism.—A few extracts from some of the great critics are subjoined to assist students in coming to an accurate appreciation of Cowper's work. Careful study and comparison are in reality the best means of obtaining an adequate conception of an author's worth, and are much to be preferred to the acceptance of the opinions of others, without perusal of the author in question.

"The gradual refinement of taste had for nearly a century been weakening the fire of original genius. Our poets had become timid and fastidious, circumscribed themselves both in the choice and management of their subjects by the observance of a limited number of models, who were thought to have exhausted all the legitimate resources of the art. Cowper was one of the first who crossed this enchanted circle, who regained the natural liberty of invention, and walked abroad in the open field of observation as freely as those by whom it was originally trodden; he passed from the imitation of poets to the imitation of nature."

"He took as wide a range in language, too, as in matter; and shaking off the tawdry incumbrance of that poetical diction which had nearly reduced the art to the skilful collocation of a set of appropriated phrases, he made no scruple to set down in verse every expression that would have been admitted in prose, and to take advantage of all the varieties with which our language could supply him."

"With not a few defects, Cowper will probably very long retain his popularity with the readers of English poetry. The great variety and truth of his descriptions; the minute and correct painting of these home scenes and private feelings with which every one is internally familiar; the sterling weight and sense of most of his observations, and, above all, the great appearance of facility with which everything is executed, and the happy use he has so often made of the most common and ordinary language, all concur to stamp upon his poems the character of original genius, and remind us of the merits that have secured immortality to Shakespeare."—*Lord Jeffrey.*

"*The Task* is less acrimonious than his first volume of poems. Its satire is altogether free from personality; it is not the satire of a sour and discontented spirit, but of a benevolent though melancholy mind; and the melancholy was not of a kind to affect artificial gloom and midnight musings, but rather to seek and find relief in sunshine, in the beauties of nature, in books and leisure, in solitary or social walks, and in the comforts of a quiet fire-side.

"No passages in a poet's works are more carped at than those in which he speaks of himself; and if he has readers after death, there are none perused with greater interest. In *The Task* there is nothing which could be carped at on that score even by a supercilious critic, and yet the reader feels that the poet is continually present; he becomes intimately acquainted with him, and it is this which gives to the poem its unity and its peculiar charm." —*Southey.*

"Cowper's verse invigorates, suggests, arouses. He never sacrifices sense to sound; never charms the ear at the expense of the understanding. Cowper understood the poet's mission —to reform the tastes and correct the follies of the age."—*Balfour.*

"Not creative imagination, nor deep melody, nor even, in general, much of fancy, or grace or tenderness is to be met with in the poetry of Cowper; but yet it is not without both high and various excellence. Its main charm, and that which is never wanting, is its earnestness. This is a quality which gives it a power over many minds not at all alive to the poetical; but it is also the source of some of its strongest attractions for those that are. Hence its truth both of landscape painting, and of the description of character and states of mind; hence its skilful expression of such emotions and passions as it allows itself to deal with; hence the force and fervour of its denunciatory eloquence giving to some passages as fine an inspiration of the moral sublime as is perhaps anywhere to be found in didactic poetry; hence, we may say, even, the directness, simplicity and manliness of Cowper's diction—all that is best in the form, as well as in the spirit of his verse. It was this quality or temper of mind that principally made him an original poet; and, if not the founder of a new school, the pioneer of a new era, of English poetry. Instead of repeating the unmeaning conventionalities and faded affectations of his predecessors, it led him to turn to the actual nature within him and around him, and there to learn both the truths he should utter, and the words in which he should utter them."—*Craik.*

To assist the student in coming to a definite conclusion upon the literary style of Cowper, his attention is directed to the following 'points.' These he can determine for himself from the criticisms given above, or from his study of the poem.

1. Cowper's choice and treatment of subjects.

2. The mechanical qualities of his style such as:

(*a.*) The metre employed and its suitability.

(*b.*) The nature of the pauses and sentences, &c.

(*c.*) His diction or the character of words employed.

3. The intellectual and emotional qualities of style, such as:

(*a.*) Strength (including earnestness, &c.)

(*b.*) Clearness, simplicity.

(*c.*) His imagery or imaginative power.

(*d.*) The nature of his satire.

(*e.*) His regard for melody.

(*f.*) His descriptive power, both of the subjective and of the objective worlds, or in other words, of mind and matter.

(*g.*) Pathos.

4. His love of nature—how it differs from Wordsworth's.

5. His subjectivity or the intrusion of self into his writings.

6. His regard for morality and Christianity.

UNIVERSITY OF TORONTO, ANNUAL EXAMINATIONS, 1881.

Junior Matriculation.

ENGLISH GRAMMAR—PASS.

1. Write a short essay on any one of the following subjects:
   (1.) The Age of Chivalry.
   (2.) The History of Universities.
   (3.) Sir Walter Scott.
   (4.) The benefits to be derived from Travel.
   (5.) "Mens sand in corpore sano."

2. Give the meaning and derivation of the following grammatical terms: *case*, *gender*, *number*, *person*, *mood*, *tense*, *voice*, and show the extent of the use of each in English.

3. Parse the following sentence:

"Love in a hut with water and a crust,
Is—Love, forgive us!—cinders, ashes, dust;
Love in a palace is perhaps at last
More grievous torment than hermit's fast."

4. How do English substantives ending in *o* preceded by a vowel form their plurals? Give four examples.

5. Mention the various sources from which the language we speak is derived, and give examples of words derived from languages which contribute only a few words each to our vocabulary.

6. Show in how far English as commonly spoken differs from English as written by the best prose authors.

7. Explain the following terms: rhyme, rhythm, prose, poetry, syntax, etymology, orthography, orthoepy, philology, linguistic.

8. "Whom say ye that I am?"
"I will arise and go unto my father."
"I shall go home now, shall you?"
Are these expressions correct? If not, point out wherein they are incorrect.

9. Give the force in composition and examples of the use of the following particles: *dis*, *a*, *cata*, *en*, *in*, *inter*, *syn*, *con*, *pro*, *pre*, *de*.

ANSWERS TO ENGLISH GRAMMAR PAPER.

BY MR. BURKHOLDER OF THE FIFTH FORM.

(a.) "Case" (cado = I fall) is the form in which a noun or pronoun is used in order to show the relation in which it stands to some other word in a sentence. There are three cases in English, the Nominative, the Possessive and the Objective, though only two distinct forms,

(b.) "Gender" (genus = kind) is a distinction in the form or use of nouns and pronouns by virtue of which they stand respectively for things of the male sex, things of the female sex, and things of the neuter sex. There are three genders in English, the Masculine gender, the Feminine gender and the Neuter gender.

(c.) "Number" (numero = I number) is a variation in the form of a word by means of which we show whether we are speaking of one thing or of more than one. There are two numbers in English, the Singular and the Plural numbers.

(d.) "Person" (persona = a mask) is a modification of the form of words by which we show whether the speaker speaks of himself or speaks of the person or persons addressed or speaks of some other person and thing.

(e.) "Moods" (modus = a manner) are the different modes in which an action or state may be asserted of the subject. There are four moods in English, the Indicative, Subjunctive, Imperative and Infinitive.

(f.) "Tense" (tempus = time) is a variation of form in verbs indicating partly the time to which an action or event is referred and partly the com-

pleteness or incompleteness of the event at the time indicated. There are six tenses, viz: Present, Present-Perfect, Past, Past-Perfect, Future, Future-Perfect.

(g.) "Voice" (voco = I call) is the form of a verb by means of which we show whether the subject of the sentence stands for the doer or for the object of the action spoken of by the verb. There are two voices in English, the Active and the Passive voice.

Love is a noun abstract, 3rd, sing., neut., subject of verb *is*.

In is a preposition connecting the words *love* and *hut*.

A is the indefinite article qualifying *hut*.

Hut is a noun com., 3rd, sing., neut., object of prep. *in*.

With is a prep. connecting the two words *hut* and *water*.

Water is a noun com., 3rd, sing., neut., object of *with*.

And is a conjunction connecting the two words *water* and *crust*.

A is the indef. art. qualifying *crust*.

Crust is a noun com., 3rd, sing., neut., object of prep. *with*.

Is is a verb, intransitive, active, ind., present, 3rd, sing. agreeing with its subject *love*.

Love is a noun abstract, 3rd, sing., neut., nom. of address.

Forgive is a verb, trans., strong, active, imperative, 2nd, sing., agreeing with its subject *thou*.

Us is a pronoun, personal, 1st, plu., masc. or fem., object of *forgive*.

Cinders is a noun com., 3rd, plural, neut., predicative nom. after verb *is*.

Ashes is a noun com., 3rd, plural, neut., pred. nom. after *is*.

Dust is a noun com, 3rd, sing., neut., pred. nom. after *is*.

Love is a noun abstract, 3rd, sing., neut., subject of verb *is*.

In is a prep. connecting the words *love* and *palace*.

A is the indef. art. qualifying *palace*.

Palace is a noun com., 3rd, sing., neuter, object after *in*.

Is is a verb, intrans., active, ind., pres., 3rd, sing., agreeing with its subject *love*.

Perhaps is an adverb, no comp., modifies *is*.

At is a prep. connecting *is* and *last*.

Last is an adjective used as a noun, 3rd, sing., object after prep. *at*.

More is an adverb of comp. degree, modifying *grievous*.

Grievous is an adjective of the positive degree, qualifying *torment*.

Torment is a noun abstract, 3rd, sing., neuter, pred. nom. after *is*.

Than is a conjunction connecting the sentences *love———torment* and *a———[is]*.

A is the indef. art. qualifying *hermit's*.

Fast is a noun common, 3rd, sing., neuter, subject of *is*.

4. By adding *s*, as cameos, folios, embryos, cuckoos.

5. (*a.*) The various sources from which our language is derived are the following:—

1. Keltic.
2. Latin of the Keltic period.
3. Saxon.
4. Latin of the Saxon period.
5. Scandinavian.
6. Norman French.
7. Modern or learned Latin and Greek.
8. Elements from Modern Languages by *travel*, *commerce*, *etc.*

(*b.*)

Seraphim	from	Hebrew.
Algebra	"	Arabic.
Caravan	"	Persian.
Scimitar	"	Turkish.
Gongs	"	Chinese.
Sago	"	Malay.
Calico	"	India.
Tattoo	"	Polynesia.
Squaw	"	North America.
Hammock	"	South America.
Charlatans	"	Italy.
Negroes	"	Spanish.
Palaver	"	Portuguese.
Yacht	"	Dutch.

Ammonia	from	Egypt.
Cyder	"	Syrian.
Malander	"	Lydian.
Tobacco	"	West Indies.

6. Speech as compared with written prose is less exact in the choice of words, more brief and varied in construction. The speaker aims at immediate effect, hence the sentences he employs are not so long or complicated as those used in writing. The speaker cannot delay to find a word to express his meaning exactly, hence he employs words that merely approximate to it, or uses some common word, such as "fine," "clever," "nice," in a very wide sense. The greater variety of speech arises in large measure from the presence of the one whom the speaker addresses, and who at any moment may interrupt or be appealed to; hence the greater vividness and abruptness of conversation.

7. For these definitions, refer to the usual text-books.

8. (*a*) "Whom say ye that I am?" is not correct. It should be "Who say ye that I am?" The pron. *who* is in the nom. case after the verb *am*.

(*b*) "I will arise and go unto my father" is correct, or rather was correct at the time when the Bible was translated: the verb *arise* and the prep. *unto* have since changed somewhat in application.

(*c*) "I shall go home now, shall you?" This sentence can be defended. See Mason's Grammar, Sec. 213, for the uses of *shall* and *will*.

Dis (apart) as Dissent, differ.
A (from) as Avert, abduction.
Cat (down) as Catalepsy, catastrophe.
En (*in* or *on*) as Emphasis, enema.
In (*in* or *into*) as Induce, impel.
Inter (among) as Interdict, introduce.
Syn (together) as Syntax, symbol.
Con (together) as Conduct, compact
Pro (before) as Promote, portray.
Pre (before) as Preterite, preturnational.
De (down) as Denote, describe.

MATHEMATICS.

First Class C—Algebra.

1. If $x^2 + y^2 + z^2 + 2xyz = 1$, then

$$z\sqrt{(1-x^2)(1-y^2)} + x\sqrt{(1-y^2)(1-z^2)} + y\sqrt{(1-z^2)(1-x^2)} = 1 + xyz \quad (1)$$

also,

$$\sqrt{\left(\frac{1+x+2yz}{1-x}\right)} + \sqrt{\left(\frac{1+y+2zx}{1-y}\right)} + \sqrt{\left(\frac{1+z+2xy}{1-z}\right)} = \frac{x+y}{1-z} + \frac{y+z}{1-x} + \frac{z+x}{1-y}$$

To prove (1) we have

$$(1-x^2)(1-y^2) = 1-x^2-y^2+x^2y^2$$
$$= z^2+2xyz+x^2y^2$$
$$= (z+xy)^2$$

$$\therefore z\sqrt{(1-x^2)(1-y^2)} = z^2 + xyz$$

similarly,

$$x\sqrt{(1-y^2)(1-z^2)} = x^2 + xyz$$
$$y\sqrt{(1-z^2)(1-x^2)} = y^2 + xyz$$

and their sum

$$= x^2 + y^2 + z^2 + 3xyz$$
$$= 1 + xyz$$

To prove (2) we have

$$\frac{1+x+2yz}{1-x} = \frac{(1+x+2yz)(1-x)}{(1-x)^2}$$
$$= \frac{1-x^2-2xyz+2yz}{(1-x)^2}$$
$$= \frac{y^2+z^2+2yz}{(1-x)^2}$$

$$\therefore \sqrt{\left(\frac{1+x+2yz}{1-x}\right)} = \frac{y+z}{1-x}$$

and similarly for the other two.

2. Solve the equations

(1). $x^2 + 4xy + y^2 = 13$
$8xy - 7x^2 + y^2 = 13$

By subtraction we get

$$8x^2 - 4xy = 0$$

$\therefore x = 0$, which gives $y^2 = 13$
or $2x = y$ " " $x^2 = 1$
and $y = \pm 2 \pm \sqrt{17}$

(2). $(1+x)^{\frac{2}{n}} - (1-x)^{\frac{2}{n}}$

$$= (1-x^2)^{\frac{1}{n}}$$

Divide through by $(1-x)^{\frac{2}{n}}$; then

$$\left(\frac{1+x}{1-x}\right)^{\frac{2}{n}} - \left(\frac{1+x}{1-x}\right)^{\frac{1}{n}} = 1$$

$$\therefore \left(\frac{1+x}{1-x}\right)^{\frac{1}{n}} = \tfrac{1}{2}(1 \pm \sqrt{5})$$

$$\therefore \frac{1+x}{1-x} = \frac{(1 \pm \sqrt{5})^n}{2^n}$$

$$\therefore x = \frac{(1 \pm \sqrt{5})^n - 2^n}{(1 \pm \sqrt{5})^n + 2^n}$$

3. (1). If a be a root of the equation $f(x) = 0$, then $x-a$ is a factor of $f(x)$.

Since a is a root of the equation, the equation must be satisfied when a is substituted in it for x; that is $f(a)$ must $= 0$. But $f(a)$ is the remainder when $f(x)$ is divided by $x - a$, $\therefore$ $x-a$ divides $f(x)$ without remainder and is $\therefore$ a factor of it.

(2). The equation

$$4x^3 - 52x^2 + 49x - 12 = 0$$

has two equal roots; find all the roots.

Express the equation thus:

$$x^4 - 13x^2 + \tfrac{49}{4}x - 3 = 0$$

and let the roots be a, a, c.

Then the sum of these roots must be equal to 13, and the sum of their products, two at a time, must equal $\frac{49}{4}$.

$$\therefore 2a + c = 13$$
$$a^2 + 2ac = \tfrac{49}{4}$$

These two equations give

$$a = \tfrac{1}{2} \text{ and } c = 12;$$

the roots of the given equations are $\therefore \frac{1}{2}, \frac{1}{2}, 12$.

(3.) The roots of the equation

$$x^4 - 10x^3 + 32x^2 - 38x + 15 = 0$$

are of the form $a+1$, $a-1$, $c+2$, $c-2$; find all the roots.

Since the sum of the roots must $= 10$ and the sum of their products two together $= 32$, we have

$$a + c = 5 \quad (1)$$

and $(a+1)(a-1) + (c+2)(c-2)$
$+ (a+1)(c+2) + (a+1)(c-2)$
$+ (a-1)(c+2) + (a-1)(c-2)$

(which reduces to

$$a^2 + c^2 + 4ac - 5) = 32$$
$$\therefore a^2 + c^2 + 4ac = 37 \quad (2)$$

From (1) and (2) we get

$$a = 2 \text{ or } 3,\ c = 3 \text{ or } 2$$

Now c cannot have the value 2, for then the root $c-2$ of the equation would be 0, but 0 is not a root of the equation.

$\therefore$ we must take $a = 2$, $c = 3$ and the required roots are 3, 1, 5, 1.

4. Sum the series

$$1^3 + 2^2 + 3^2 + 4^2 + \&c. + n^2.$$

See Todhunter's Algebra, § 460.

5. Show how to find the sum of an arithmetical progression, having given the first term, common difference and number of terms.

Sum to n term, the series whose first term is a, and the succession differences $b, 2b, 3b, \ldots (n-1)b$.

This series is a, $a+b$, $a+b+2b$, &c., the last term being

$$a + b + 2b + \ldots (n-1)b,$$

$$\text{which} = a + \frac{n}{2}(n-1)b.$$

$\therefore$ the sum of the series $= na$

$$+ b\left\{1 + 3 + 6 + 10 + \ldots + \frac{n}{2}(n-1)\right\}$$

The series 1, 3, 6, 10, ..., observing that the last term is $\frac{n^2 - n}{2}$, may be arranged thus

$$\frac{1^2 - 1}{2} + \frac{2^2 - 2}{2} + \frac{3^2 - 3}{2} + \dots$$

$$= \tfrac{1}{2}(1^2 + 2^2 + 3^2 + \dots + n^2) - \tfrac{1}{2}(1 + 2 + 3 + \dots + n)$$

$$= \frac{n}{12}(n + 1)(2n + 1) - \frac{n}{4}(n + 1)$$

$$= \frac{n}{6}(n^2 - 1)$$

∴ sum of the original series

$$= na + \frac{n}{6}(n^2 - 1)b$$

6. (1). Sum to n terms the series

$$1 + 2x + 5x^2 + 7x^3 + \dots$$

Let $S = 1 + 3x + 5x^2 + \dots + (2n-1)x^{n-1}$
then $Sx = x + 3x^2 + \dots + (2n-3)x^{n-1} + (2n-1)x^n$.

∴ by subtracting we get

$$S(1-x) = 1 + 2x + 2x^2 + \dots + 2x^{n-1} - (2n-1)x^n$$

$$= 1 + 2(x + x^2 + \dots + x^{n-1}) - (2n-1)x^n$$

$$= 1 + 2x\frac{x^{n-1} - 1}{x - 1} - (2n-1)x^n$$

$$\therefore S = \frac{1}{1-x}(\dots).$$

(2). If the natural numbers be divided into groups $1, 2 + 3, 4 + 5 + 6$, &c., find the sum of the nth group, also the sum of the first n groups, and thence deduce the sum of

$$1^3 + 2^3 + 3^3 + \dots + n^3.$$

The last numbers in the groups are

$$1, 3, 6, 10, \dots \frac{n}{2}(n-1), \frac{n}{2}(n + 1).$$

∴ the first number in the last group is $\frac{n}{2}(n-1) + 1$ ∴ the sum of the last group is

$$\frac{n}{2}\left(\frac{n}{2}\overline{n-1} + 1 + \frac{n}{2}\overline{n+1}\right)$$

$$= \frac{n}{2}(n^2 +).$$

To find the sum of the first n groups we have to find the sum of the natural numbers from 1 to $\frac{n}{2}(n + 1)$. This sum is

$$\frac{n}{4}(n + 1)\left(\frac{n}{2}\overline{n+1} + 1\right)$$

$$= \tfrac{1}{2}\left(\frac{n}{2}\overline{n+1}\right)^2 + \tfrac{1}{2}.\frac{n}{2}\overline{n+1}. \quad (a)$$

To deduce the sum of $1^3 + 2^3 + \dots$.

The sum of the nth group is $\frac{n^3 + n}{2}$

∴ sum of 1st group is $\frac{1^3 + 1}{2}$

sum of 2nd group is $\frac{2^3 + 2}{2}$

&c.

∴ S (the sum of all the groups) is

$$= \tfrac{1}{2}(1^3 + 2^3 + 3^3 + \dots + n^3) + \tfrac{1}{2}(1 + 2 + 3 + \dots + n)$$

$$\therefore 1^3 + 2^3 + 3^3 + \dots + n^3 = 2S - \frac{n}{2}(n + 1)$$

$$= \left(\frac{n}{2}\overline{n+1}\right)^2 \text{ from } (a).$$

7. Find the number of combinations of n things r together.

On a shelf are 20 books, of which 5 volumes are of one set, 3 of another, and 2 of another, and the rest are all odd books; find the number of different arrangements that can be made with them, each set being kept intact, though the order of books in it may be changed.

There are 3 sets and 10 odd books, and the number of different arrangements that can be made of the 13 things is $|\underline{13}$. For each one of these $|\underline{13}$ arrangements, the 5 volumes in the first set may be arranged in $|\underline{5}$ ways, thus making $|\underline{5}\ |\underline{13}$; and so on for the other two sets, so that altogether there will be

$$|\underline{2}\ |\underline{3}\ |\underline{5}\ |\underline{13}$$

different arrangements.

8. Two equal circles touch a straight line at A and B, and do not intersect; and on each of them at equal intervals are situate $2n + 1$ points, A and B being such points. The only lines that contain more than two of the points are those that are parallel to AB. Find the number of triangles that can be formed by joining these points—both circles being utilized for each triangle.

The number of pairs of points on the circle A is the number of combinations of $2n + 1$ things 2 together, that is, $n(2n + 1)$. If now we suppose that no line contains more than two points, then each of the $n(2n + 1)$ pairs of points in A will form a triangle with each of the $2n + 1$ points in B; there will ∴ be $n(2n + 1)(2n + 1)$ triangles, each of which has *one* angular point on the circle B. Similarly then will be the same number of triangles having one angular point on A; that is, there would be $2n(2n + 1)(2n + 1)$ triangles altogether. But each one of the n lines parallel to AB prevents the formation of four triangles, ∴ our first result must be diminished by $4n$, which gives

$$2n(4n^2 + 4n - 1).$$

9. Show how to determine the greatest term in the expansion of $(a + x)^n$.

10. (1) The coefficient of x^r in the expansion of

$$(1 - x)^{-\frac{3}{2}} \text{ is } \frac{\lfloor 2r + 1}{\lfloor r \lfloor r} \cdot \frac{1}{2^{2r}}.$$

The expansion of $(1 - x)^{-\frac{3}{2}}$ is

$$1 + 3\left(\frac{x}{2}\right) + \frac{3.5}{1.2}\left(\frac{x}{2}\right)^2 + \frac{3.5.7}{1.2.3}\left(\frac{x}{2}\right)^3 + \ldots$$

∴ coefficient of x^r is

$$\frac{3.5.7.9.\ldots(2r + 1)}{2^r \lfloor r}, \quad (a).$$

Now since $2.4.6.\ldots 2r$

$$= 2^r (1.2.3\ldots r) = 2^r \lfloor r$$

if we multiply the num'r of (a) by $2.4.6.\ldots r$ and its denominator by $2^r \lfloor r$, the value of (a) will not be altered and it becomes

$$\frac{1.2.3.4.5.6.\ldots 2r + 1)}{2^{2r} \lfloor r \lfloor r}$$

(2) If a_r be the coefficient of x^r in the expansion of $(1 + x)^n$; then, n being a positive integer,

$$\frac{a_1}{a_0} + \frac{2a_2}{a_1} + \frac{3a_3}{a_2} + \ldots + \frac{na_n}{a_{n-1}}$$

$$= \frac{n}{2}(n + 1).$$

We have $a_0 = 1$, $a_1 = n$,

$$a_2 = \frac{n(n-1)}{1.2}, \; a_3 = \frac{n(n-1)(n-2)}{1.2.3}, \ldots$$

$$\therefore \frac{a_1}{a_0} = n,$$

$$\frac{2a_2}{a_1} = n - 1,$$

$$\frac{3a_3}{a_2} = n - 2,$$

&c. = &c.

$$\frac{na_n}{a_{n-1}} = 1,$$

∴ the sum required is the sum of the first n natural numbers, or

$$\frac{n}{2}(n + 1).$$

MECHANICS.—*1st C.*

1. Define a couple and show that the forces composing one do not admit of a single resultant.

State the various transformations that may be made on a couple without alteration of effect. Establish the truth of one of them.

The sides of a quadrilateral are acted on by forces perpendicular to them, and proportional to them in magnitude, the forces being turned inwards. Show that if the points of application divide the sides in a constant ratio they reduce to a couple.

This result will readily appear if the forces be resolved at right angles and along one of the sides. The forces may produce equilibrium.

2. Find the centre of gravity (1) of a triangular area; (2) of three uniform rods forming a triangle.

In the latter case if the system be suspended by a string attached to a point in one of the sides, find the position of the point that the triangle may rest with one side vertical.

When the triangle is at rest the line joining the centre of gravity and the point of suspension must be vertical, and ∴ parallel to the vertical side; ∴ the point of suspension is one of the points of trisection of the side in which it is, and is the one nearer the vertical line.

3. State Newton's Laws of Motion, and explain the nature of the reasoning by which they are arrived at.

Show how the second and third enable us to exhibit dynamic phenomena by means of equations.

4. (1.) A gun (wt. 3 tons) rests on a plane of inclination 30° to the horizon, being pointed downwards parallel to the plane; a shot of 60 lbs. is discharged from it with a velocity of 1,500 feet per second. Find how far up the plane the gun will recoil.

The gun being 100 times the mass of the ball will recoil with $\frac{1}{100}$ of its velocity, that is with a velocity of 15 feet per second. And since the force of gravity will cause a retardation down the plane equal to $\frac{1}{2}g$, ∴ the motion of the gun will be stopped in $\frac{30}{g}$ seconds; during this time the gun may be supposed to move with a uniform velocity of $7\frac{1}{2}$ feet per second. The distance required is

$$\therefore 7\tfrac{1}{2} \times \frac{30}{g} = 7 \text{ feet nearly.}$$

(2.) Two weights of 5 and 10 lbs. are attached by a string, the heavier hanging vertically from the edge of a smooth horizontal table on which the lighter rests. Determine the motion.

Substituting in the formula

$$f = \frac{P}{W} g \text{ we get}$$

$$f = \tfrac{10}{15} g$$

Which determines the motion.

5. The Normal pressure on a surface exposed to the action of fluid is equal to the pressure on a plane horizontal surface of equal area at the same depth below the surface, that the centre of gravity of the first surface is, gravity being the only force acting.

A tetrahedron whose faces are equilateral triangles is just filled with fluid and has three of its corners in a horizontal plane; show that when the fourth is above this plane, the total pressure on all the sides is three times the total pressure when this corner is below the plane.

Since the fluid is the same and the extent of surface in contact with it, the same, it follows that the total pressure will vary as the depth of the centre of gravity of the surface below the highest point of the fluid; and since this depth is three times as great in the first case as in the second; ∴ the pressure must be so also.

6. When a body is immersed in a fluid it loses a portion of its weight equal to the weight of the displaced fluid.

A sphere of radius a is composed of a substance n times heavier than water; find the radius of a spherical portion that must be hollowed from its inside that it may float in water with $\frac{1}{n}$th of its volume above the surface.

If the volume of the sphere be taken as the unit of volume, then the sphere is heavy enough to displace a volume of water whose measure is n; but after part is removed the remainder can only displace a volume of water whose measure is $\frac{n-1}{n}$.

∴ volume of sphere : volume of part left as $n : \frac{n-1}{n} = n^2 : n-1$.

∴ sphere : part removed as $n^2 : n^2-n+1$. and the ratio of radii will be the cube root of this, ∴ the radius required $= a\sqrt[3]{\frac{n^2-n+1}{n^2}}$

EUCLID—*1st C.*

1. Where would the difficulty in the theory of parallel lines present itself, if they were

defined to be such that a transversal falling on them made the alternate angles equal?

2. If there be two straight lines the rectangle contained by their sum, and one of them is equal to the square on that one together with the rectangle contained by the two straight lines.

3. In any triangle the squares on the two sides are together double of the squares on half the base and on the straight line joining its bisection with the opposite angle. If a point be taken such that the sum of the squares on the lines joining it to the angular points of a square is equal to three times the square itself, the focus of the point is a circle whose diameter is equal to a side of the square.

4. The angle at the centre of a circle is double the angle at the circumference upon the same part of the circumference.

Hence show that the angle in the segment less than a semi-circle is greater than a right angle, and in one greater than a semi-circle is less than a right angle.

5. If a point be taken within a circle, the rectangle under the segments of any chord through it is constant. Prove only the general case.

Given the vertical angle and base of a triangle, and also the rectangle contained by the difference between the other two sides and one of them, construct the triangle.

6. Describe a circle to touch three given straight lines.

If the three points in which an escribed circle of a triangle touches the sides be joined, the triangle so formed will be obtuse-angled.

7. AB is a given line, C its middle point, and D another fixed point in it. CE is drawn at right angles to AB and in it any point F is taken; FD is produced to G, so that as F changes its position in CE the rectangle FD, DG is always equal to the rectangle AD, DB. Show that the locus of G is a circle.

8. Triangles of the same altitude are one to another as their bases. Triangles are to one another in the ratio compounded of the ratios of their altitudes and bases. Prove this after the manner of Euclid.

9. To describe a rectilineal figure that shall be similar to one and equal to another given rectilineal figure.

A offers to run three times round a course while *B* runs twice round, but *A* only gets 150 yards of his third round finished when *B* wins, *A* then offers to run four times round for *B*'s thrice, and now quickens his pace so that he runs four yards in the time he formerly ran three. *B* also quickens his so that he runs nine yards in the time he formerly ran eight, but in the second round falls off to his original pace in the first race, and in the third round only goes nine yards for ten he went in the first race, and accordingly this time *A* wins by 180 yards. Determine the length of the course.

Let x = *A's* rate in yards per minute.

" y = *B's* " " "

and z = Length of course in yards.

Then in the first race *A* goes $2z + 150$ yds., while *B* goes $2z$ yds.; ∴ *A*'s time is $\frac{2z + 150}{x}$ min. and *B*'s is $\frac{2z}{y}$ min.

$$\therefore \frac{2z}{y} = \frac{2z + 150}{x} \quad (1)$$

In the second race *A*'s time is $\frac{4z}{\frac{4x}{3}}$ or $\frac{3z}{x}$ min., and *B*'s is

$$\frac{z}{\frac{9y}{8}} + \frac{z}{y} + \frac{z-180}{\frac{9y}{10}} \text{ or } \frac{3z-200}{y} \text{ min.}$$

$$\therefore \frac{3z}{x} = \frac{3z-200}{y} \quad (2)$$

$\therefore 3zx - 3yz = 225y$ From (1)

and $3zx - 3yz = 200x$ " (2)

$\therefore 8x = 9y$

Multiply the first term of (1) by $9y$ and the second by $8x$ and we get $z = 600$.

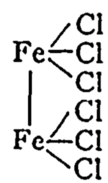
SCIENCE DEPARTMENT.

GROUP IV.

METALS: Zinc, Manganese, Nickel, Cobalt, Iron.

(By Miss Jennie Wood.)

PROPERTIES OF THE GROUP.—The metals of the IV. Group are precipitated by Sulphuretted Hydrogen, H_2S., *completely* out of Alkaline, imperfectly out of Neutral, and not at all out of Acid (strong free acid) Solution. Ammonium Sulphide, NH_4HS (=H_2S and NH_3) produces the same reaction. The precipitated Sulphides (ZnS, MnS, NiS, CoS, FeS) are insoluble in water, but readily soluble in dilute acids (NiS and CoS difficultly soluble). Ammonium Sulphide, NH_4HS, distinguishes the metals of this Group from those of I. and II. Groups, which were *non-precipitable*, and from those of the III. Group, which were precipitable not as Sulphides but as Hydroxides. The metals of this Group are bivalent, quadrivalent or sexivalent. Zinc is always bivalent, ZnO being its only oxide. Manganese, Nickel, Cobalt and Iron are bivalent in their Manganous (MnO, $MnCl_2$, &c., &c.), Nickelous (NiO, $NiCl_2$ &c.), Cobaltous (CoO, $CoCl_2$, &c.) and Ferrous (FeO, $FeCl_2$, &c.) compounds, and *quadrivalent* in their Manganic (Mn_2O_3, Mn_2Cl_6, &c.), Nickelic (Ni_2O_3), Cobaltic (Co_2O_3) and Ferric (Fe_2O_3, $Fe_2(SO_4)_3$, Fe_2Cl_6) compounds. It is by the union of two atoms by one combining power that the hexad group is formed :—



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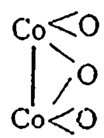
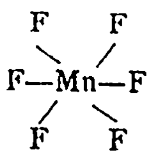
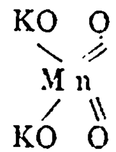
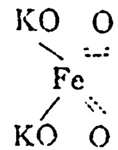


&c.

Cobalt and Nickel are bivalent in their ordinary salts, the peroxides or sesquioxides, Co_2O_3, and Ni_2O_3, losing oxygen at a red heat. Besides these oxides, the *tetradic* combinations of Nickel and Cobalt are *very few*. Manganese and Iron are also sexivalent—Manganese Sex-fluoride MnF_6, Potassium Manganate K_2MnO_4, and Potassium Ferrate K_2FeO_4







I.—SYMBOL.

Zu. C.W. 65 (64·9), S. G. 6·8 to 7·2, Mn. C.W. 55 (54·8), S.G. 8·0, Fe. C.W. 56 (55·9), S.G. 7·8, Ni. C.W. 58·6, S.G. 8·8, Co. C.W. 58·6, S.G. 8·5.

II.—OCCURRENCE.

Zu.	Mn.	Ni.	Co.	Fe.
Chief ores are :— Zinc Blende, Zu S. Zincite, ZnO (red zinc ore) and Calamite, Zn CO_3.	:— Braunite, Mn_2O_3. Hausmannite, Mn_3O_4. Pyrolusite, Varvasite, { Mn O_2. Diallogite, Mn CO_3. Manganite, Mn_2O_3,H_2O.	:— (*a*) Free — accompanying Fe in Meteoric Iron. (*b*) Combined. Nicollite (Copper Nickel) Ni As. Gersdorffite (Nickel Glance) Ni S As.	:— (*a*) Free—same as Nickel. (*b*) Combined. Smaltite (Cobalt speis, tin white Cobalt), Co (Fe Ni) As_2. Cobaltite (Cobalt Glance) Co As S.	:— (*a*) Free in Meteoric Iron. (*b*) Combined. *Hematite* (Specular Iron) Fe_2O_3. *Limonite* (brown hematite) $2Fe_2O_3+3H_3O$. *Gothite*, Fe_2O_3 + H_2O. *Magnetite*, Fe_3O_4. *Siderite* (Spathic Iron) Fe CO_3. *Pyrite* (iron pyrites). *Marcasite* (white iron pyrites). } Fe S_2. *Pyrrhotite* (magnetic pyrites) Fe_7S_8.

III.—PREPARATION.

(1) The Sulphide or Carbonate is roasted at a high temperature in order to convert it into the oxide.	(1) The metal is obtained with difficulty by the reduction of the oxide by heating it with Charcoal, at a very high temperature.	(1) The metal in the form of a grey pyrophoric powder may be prepared, on a small scale, by the reduction of the oxide in a stream of hydrogen gas.	(1) Same as Nickel; powder is dark grey, also pyrophoric.	(1) A button of pure iron may be obtained by exposing fine iron wire, mixed with some oxide of iron (FeO, Fe_2O_3 or Fe_3O_4) and powdered glass, to a high temperature in a covered crucible. The Carbon of the iron wire is burned by the oxygen of the oxide—the oxide in excess is taken up by the molten glass.
(2) The oxide is then reduced by strongly heating it with Carbon—Carbon Monoxide escapes, the metallic Zinc distils over, and may be condensed.	(2) By the reduction of Manganous Fluoride by means of Sodium.	(2) By strongly heating Nickelous Oxalate, NiC_2O_4.	(2) and (3) Same as Nickel, but in a compact condition.	(2) Pure iron, in the form of a black powder, is obtained by the reduction of the oxides at a moderate heat in a current of hydrogen. This powder (so called Pyrophorous) immediately takes fire and burns to oxide when exposed to the air.
	(3) By the reduction of a mixture of Manganous Chloride and Calcium Fluoride by means of Sodium.	(3) In a fused state by the reduction of its oxide by means of Charcoal at a white heat.		(3) If a stream of dry hydrogen gas be passed over heated Ferrous Chloride $Fe Cl_2$ contained in a glass tube, a bright metallic mirror of pure iron will be found coating the side of the tube.

IV.—PROPERTIES.

A bluish-white, very bright metal of medium hardness, malleable at a temperature between 100° and 150° but otherwisr more or less brittle (so brittle at 200° can be powdered); melts at 423°, and begins to boil at a bright red heat, and burns with a bluish-green flame, giving off white fumes of Zinc Oxide, ZnO. Exposed to the air it loses its metallic glance—a thin coating of the oxide forming on its surface, which resists further action. Iron covered by it is said to be "galvanized." Brass is an alloy of one part Zinc and two Copper. German Silver is an alloy of Zinc, Nickel and Copper. Zinc dissolves in dilute Hydrochloric and Sulphuric acids with evolution of Hydrogen gas; in dilute Nitric acid with evolution of Nitrous Oxide N_2O; in more concentrated Nitric acid with evolution of Nitric Oxide, NO.	A reddish-white (whitish-grey), dull, very hard (scratches glass), brittle, difficultly fusible metal. It oxidizes rapidly in air; decomposes water at the ordinary temperature with the evolution of Hydrogen; must be kept under naphtha or in sealed tube. It has no use in the arts. An alloy of Manganese and Iron is used in the manufacture of Steel. Some of its oxides are used to evolve Chlorine from Hydrochloric acid and to tint glass a purple colour. It dissolves readily in acids forming Manganous Salts.	Nickel in the fused state is a yellowish-white (inclining to grey), hard, malleable tenacious, difficultly fusible, strongly magnetic (losing this property when heated to 350° C) metal. It does not oxidize in the air at the ordinary temperature, it slowly oxidizes upon ignition. It slowly dissolves in Hydrochloric acid and dilute Sulphuric acid upon the application of heat with the evolution of Hydrogen gas. It dissolves readily in Nitric acid. The solutions contain Nickelous Salts.	Cobalt in the fused state is a steel-grey, hard, malleable, tenacious, difficultly fusible (infusible as iron), strongly magnetic metal which is susceptible of a fine polish. Same, but oxidizes at a red heat. Same. Solutions contain Cobaltus Salts.	Metallic iron in the pure state, has a light, whitish-gray color. The metal is hard, lustrous, malleable, ductile, very difficultly fusible, crystallizable (cubes); is attracted by the magnet; has a granular or crystalline structure when uniformly hammered, a fibrous when rolled in bars. Long continued vibration changes the fibrous condition to the crystalline (cause of the sudden snapping of railway axles). It becomes soft before it melts, hence, two clean surfaces of the hot metal may be '*welded*' if hammered together. In contact with air containing moisture, a coating of rust, Ferric Hydroxide $Fe_2(OH)_6$ forms on its surface. Heated in air or plunged in oxygen gas, it burns, forming black ferrosoferric

oxide, Fe_3O_4. It decomposes steam at a red heat, liberating hydrogen and forming the black oxide, Fe_3O_4. Iron forms two basic oxides, Ferrous, FeO, and Ferric, Fe_2O_3. Iron dissolves in Hydrochloric Acid and dilute Sulphuric Acid, with the evolution of Hydrogen. Solutions contain Ferrous Salts. If Iron contains Carbide, the Hydrogen is mixed with Hydrocarbons. Dilute Nitric Acid dissolves Iron in the cold to Ferrous Nitrate, $Fe(NO_3)_2$ with the evolution of N_2O; at a high temperature, to Ferric Nitrate, $Fe_2(NO_3)_6$ with the evolution of NO.

There are three commercial forms of Iron—Wrought Iron, Cast Iron and Steel—differing in properties and chemical composition. The first is nearly pure Iron; the second is Iron with varying quantities of Carbon and Silicon; the third has less Carbon than Cast Iron.

PREPARATION OF THESE COMMERCIAL FORMS

(1.) In the oldest method, Wrought Iron was at once obtained by heating the ore in a wind furnace with charcoal.

(2.) In the modern method, Cast Iron is the first product.

(a) The ore, if it is Siderite, $FeCO_3$ (clay is generally present as impurity), is first roasted, the Carbonic Acid CO_2 is driven off and Ferric Oxide Fe_2O_3 remains.

(b) The Ferric Oxide (or ore Hematite Fe_2O_3, or Magnetic Iron ore Fe_3O_4) is placed with limestone and coal in a *blast furnace.*

(c) The Ferric Oxide, in its passage from the top to the bottom of the furnace, is reduced to a porous mass of Metallic Iron by the Carbonic Oxide, CO, proceeding from the lower layers of burning coal, $Fe_2O_3 + 3CO = Fe_2 + 3CO_2$. The heat here is not sufficient to fuse the Iron.

(d) "The clay, sand and other impurities of the ore, unite with the limestone to form a fusible silicate or slag, whilst the heated metal coming in contact with the Carbon (charcoal), unites at once with it to form a fusible compound, which runs down to the bottom of the furnace. This molten metal in passing through the hottest portion of the furnace, reduces the Silica, SiO_2, with which it meets to *Silicon*, and combined with this and with the Carbon it forms Cast Iron."

(3.) Wrought Iron is obtained from Cast Iron by the processes of "*refining*" and "*puddling*."

(a) The Carbon, Silicon, Sulphur and Phosphorous, are burnt out by exposing the heated metal to a current of air in a reverberatory furnace.

(b) The melted Cast Iron becomes first covered with a coat of Oxide; gradually thickens, and is then rolled into balls; all the Carbon is oxidized to Carbonic Oxide CO, the Silicon to Silica SiO_2 (which unites with the Oxide of Iron and forms a fusible slag). P. and S. are also oxidized by this process.

(c) The ball is hammered to give the metal coherence and to squeeze out the liquid slag, and the mass is afterwards rolled into bars and plates.

(4.) Steel is formed when bars of Wrought Iron are heated to redness for some time in contact with charcoal.

(a) In the Bessemer process, the Carbon and Silicon are burnt out by passing a blast of atmospheric air through the molten metal. Enough pure Cast Iron is now added to this Wrought Iron to convert the whole mass into Steel.

PROPERTIES OF THESE COMMERCIAL VARIETIES.

(1) Cast Iron is not a definite compound of Carbon and Silicon with Iron, hence its appearance and properties will vary with the quantity of Carbon and Silicon present. "Carbon is found in Cast Iron, (1) as scales of graphite, giving rise to grey or mottled Cast Iron; and (2) in combination, forming white Cast Iron." It is lighter and more easily fused than the other varieties of Iron; is brittle, and can not be *welded*. Treated with acids, it develops evil-smelling Hydrocarbons, &c.

(2) Wrought Iron is nearly pure Iron (having not more than $\frac{1}{2}$ proc. of Carbon, with traces of Silicon and Manganese). It melts only at the highest white heat, is fibrous, very tenacious, capable of polish, can be welded, &c.

(3) Steel contains about one proc. of Carbon (Nitrogen and traces of Silicon, Aluminium and Manganese). Steel has a grey-white color; is fine-grained, less tenacious and harder than Wrought Iron, capable of the highest polish, becomes very hard and brittle when quickly cooled. Heat changes the color of Steel: at 215°C (heated in air) it becomes *straw yellow*, then dark blue and purple; at 282°C, violet, then dark blue, and finally light blue.

PUBLIC SCHOOL DEPARTMENT.

HOW TO TEACH MENTAL ARITHMETIC.*

BY J. H. KNIGHT, P. S. INSPECTOR, LINDSAY.

Continued from page 115.

EXERCISE VII.

Addition and Subtraction.

For this exercise a space on the floor of the school-room is required of sufficient length to allow the whole class to stand in a straight line, and of sufficient depth for at least two ranks of pupils.

Instructions to the Teacher. Place the class on the floor in a straight line, and let them number forwards and backwards until each pupil is familiar with his own number. In a class of 12 the first position will be as follows:

1 2 3 4 5 6 7 8 9 10 11 12

At the word "one," let No. 1 extend the left hand horizontally from the elbow; at 3, 5, 7, &c., the other odd numbers do the same. At the word "forward," all the odd numbers step forward one pace with the left foot, halt, and drop the left hand: thus 2nd position.

2	4	6	8	10	12
1	3	5	7	9	11

Let each rank number forwards and backwards, each pupil saying his own number. The teacher may give the word of command "Front rank number forwards," "Front rank number backwards," "Rear rank number forwards," "Rear rank number backwards," or 1, 11, 2, 12 respectively, or point to the pupil who is to begin, or merely look at him. This exercise will teach pupils to add and subtract by twos. The position of the pupils should be changed from day to day. After a time the lowest number may be some other than one, for instance the numbers may be from 7 to 18, and afterwards from 13 to 24.

In a mixed school, where the classes are small, it will be better to put two or more classes together, than to have the class too small.

After a time the pupils may number by twos forwards and backwards, commencing with 2 at first, then with 1, and after that with any other number. This may be done with the pupils in a straight line, the pupil at the top of the class following the pupil at the bottom through any number of rounds.

To number by threes, the pupils may stand in three ranks, numbers 1, 4, 7, 10 stepping forward two paces, numbers 2, 5, 8, 11 stepping forward one pace, and numbers 3, 6, 9, 12 remaining at the first position, thus:

		3			6			9			12
	2			5			8			11	
1			4			7			10		

If found more convenient, all the pupils may step forward one pace, then, 1, 4, 7 and 10 may step forward one pace more, 3, 6, 9 and 12 one pace to the rear, and 2, 5, 8 and 11 remain in position. The word of command will vary to suit the three Nos. 2, 5, 8 and 11 being called the Middle Rank. The position of the pupils should be changed from day to day so that the same pupil may not constantly have the same number. Higher numbers may be taken after a time as in the case of numbering by twos, after which the numbering by threes may be done by the pupils standing in a straight line. At first take the numbers 3, 6, 9, 12, &c., then 1, 4, 7, 10, &c., then 2, 5, 8 11, &c., after which they may number backwards commencing with any number named by the teacher.

To number by fours it will be merely necessary for the pupils to stand in a straight line. Take the numbers 4, 8, 12, 16, &c., at first, and number forwards and backwards. Then take 1, 5, 9, 13, &c., then, 2, 6, 10, 14, &c., then, 3, 7, 11, 15, &c. The higher numbers may be dealt with in the same way.

As soon as pupils are expert in adding by twos they may be taught Addition on slates with ones and twos. The exercise in Mental Arithmetic with threes may then be taken, and after that Addition on slates with figures 1, 2 and 3. Proceed with the other numbers up to 9, paying particular attention to Addition, that is adding or numbering forwards. When the pupils come to Subtraction on slates more attention should be paid to numbering backwards, that is Subtraction. Numbering by elevens and twelves may be taken when pupils come to Multiplication. Numbering by numbers higher than 12 may be taken occasionally while pupils are in Compound Rules, so that by the time they come to Greatest Common Measure and Least Common Multiple they may be familiar with the measures of all numbers they have to deal with.

EXERCISE VIII.

Multiplication.

Let the pupils stand on the floor in a straight line and number first by ones and then by twos. Each pupil will have two numbers, thus:

1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24

Each pupil may then say both numbers in succession thus 1, 2; 2, 4; 3, 6; &c., forwards and backwards. The first pupil may then say twice 1 are 2; the second pupil twice 2 are 4; and so on, each pupil keeping to his own numbers. When they are expert in saying this both forwards and backwards, the teacher may put the questions promiscuously, requiring the proper pupil to give the answer. The position of the pupils should be changed from time to time, so that each pupil may learn the whole of the table.

Proceed in the same manner with the other tables.

The most convenient number of pupils for a class in this exercise is 12. In a mixed school pupils from a higher class may be drafted in to make up the number if required. When the class consists of more than 12 and less than 24, it may be divided into sections of 12, the dullest pupils being drafted into both sections. When the number of pupils is less than 12, the table may be learned by parts; for instance, if there be 8 pupils, they may number at first from 1 to 8, and afterwards from 5 to 12. When there are 14 or 15 in the class, the table may be extended.

EXERCISE IX.

Prime and Composite Numbers.

Let the pupils answer in turn, without waiting for any word or signal from the teacher. As soon as one has finished, the next proceeds. If the pupils stand on the floor, when one misses or answers incorrectly, the next who answers corectly goes up. When pupils remain at their desks all stand at the commencement, and each sits as he answers correctly. Those who fail remain standing and take a second turn after all the others have tried.

One is a prime number.
Two is a prime number.
Three is a prime number.
The factors of four are 2 and 2.
Five is a prime number.
The factors of six are 2 and 3.
Seven is a prime number.
The factors of eight are 2 and 4.
The factors of nine are 3 and 3.
The factors of ten are 2 and 5.
Eleven is a prime number.
The factors of twelve are 2 and 6, 3 and 4.
Thirteen is a prime number.
The factors of fourteen are 2 and 7.
The factors of fifteen are 3 and 5.
The factors of sixteen are 2 and 8, 4 and 4.
Seventeen is a prime number.
The factors of eighteen are 2 and 9, 3 and 6.
Nineteen is a prime number.
The factors of twenty are 2 and 10, 4 and 5.
The factors of twenty-one are 3 and 7.
The factors of twenty-two are 2 and 11.
Twenty-three is a prime number.
The factors of twenty-four are 2 and 12, 3 and 8, 4 and 6.

The above may be carried as far as considered desirable. When there are more than two factors, begin with the lowest and take the pairs of factors in order. This exercise may commence with any other number than one when the pupils are familiar with the first part of the exercise. As a subsequent exercise the prime numbers may be taken separately. The composite numbers may be taken separately in order, or promiscuously as named by the teacher.

To be continued.

QUESTIONS USED AT THE MODEL SCHOOL PROFESSIONAL EXAMINATION AT LINDSAY, OCTOBER 21st AND 22nd, 1881.

SCHOOL LAW AND REGULATIONS.

1. What are the essential points of an agreement between trustees and teacher?

2. Name the vacations and holidays in Public Schools.

3. Under what conditions may the summer vacation be shortened?

4. For what offences may a pupil be suspended?

5. What business should be transacted at an Annual School Meeting?

6. What should the half-yearly report contain?

7. Describe the General Register.

8. What are the regulations respecting (1) presents to teachers, (2) contagious diseases, (3) punctuality of pupils.

MENTAL ARITHMETIC.

1. Quotient 1250, divisor 12, remainder 8; find dividend.

2. MDL + LXI + XIX.

3. A can do a work in 2 days, B in 3 days. In what time can A and B do it?

4. Exchanged 11 tons hay for 15 sheep at $6 each, and 4 sheep at $5 each. What was the hay per ton?

5. What number multiplied by 9 = 7236 × 5?

6. Bought cloth at .27 and sold it at .24; what did I lose %?

7. $\frac{3}{5}$ of 100 is $\frac{3}{250}$ of $\frac{1}{5}$ of what number?

8. Reduce £3 3s. 3d. to dimes, and divide equally among 23 boys.

9. If $\frac{2}{3}$ of a herring cost $\frac{3}{5}$ of a dime, how many herrings will 90 cents buy?

10. Reduce 15 days to minutes.

HYGIENE.

1. State the chief evils arising from breathing impure air.

2. Describe the structure of the human ear, and tell the rules to be observed in the care of it.

3. State fully the precautions that should be taken to prevent the spread of contagious diseases.

4. What method would you take to restore a person apparently drowned.

5. Name (1) the principal, (2) the accessory organs of digestion.

6. Give at least six rules the observance of which would conduce to proper digestion.

EDUCATION AND SCHOOL ORGANIZATION.

1. Construct a Time-table for a school of 50 pupils in 1st, 2nd, 3rd and 4th classes.

2. What arithmetic should be taught in the third class, and what Geography in the 4th class?

3. How would you begin to teach (1) Dictation, (2) Composition, and (3) History?

4. Discuss the daily marking of recitations.

5. How would you encourage cleanliness, punctuality and honesty in pupils?

6. What rules would you adopt with respect to pupils when not reciting in order to secure quietness?

7. What purposes, besides teaching spelling, may Dictation serve, and how may these purposes be accomplished?

USEFUL KNOWLEDGE.

(From Nelson's Royal Readers.)

THE EARTH.

Form.—What is the Form of the Earth? It is round like an orange or a ball.

What is the Whole Globe called? A sphere.

What is the Half of it called? A hemisphere or half-sphere.

How could you see the whole of an orange at once? By cutting it in two, and placing the halves side by side.

How can you see a picture of the whole Globe at once? By placing pictures of the two Hemispheres side by side.

Surface.—Of what does the Surface of the Globe consist? Of Land and Water.

Of which is there most? Of the

water: it covers three times as much space as the land.

How is the Land-surface of the Globe divided? Into low-lands, which are nearly at the level of the sea; and high-lands, which are much above the level of the sea.

How is the Water-surface of the Globe divided? Into the sea, which surrounds the land; and rivers which drain the land, and flow into the sea.

What are the Lakes? When a river, on its way to the sea flows into a deep hollow or basin, it must fill that up before it can flow any further. This hollow filled with water is called a Lake.

What is the largest body of Water called? An Ocean.

And the largest body of Land? A Continent.

What is a portion of land with water all round it? An Island.

If it has water round it in all parts but one? A Peninsula, which means "almost an island."

What is an Isthmus? A narrow neck of land joining two larger portions.

What is a narrow neck of Water joining two larger portions? A Strait.

And a passage wider than a Strait? A channel.

What is a Cape? A point of land jutting into the sea.

What is a body of Water stretching into the Land? A Gulf or Bay.

What is a Mountain? A portion of land rising high above the country around it.

What are the smaller High-lands? Hills.

And Burning-mountains? Volcanoes.

What is a tract of country lying between Hills? A valley or dale.

What is a Plain? A broad portion of country nearly flat or level.

If the Plain is high up amongst Hills? A Table-land.

MOTIONS OF THE EARTH.

Day and Night.—Is the Earth standing still? No: it is constantly turning round—spinning like a top—carrying everything on it round with it.

How much of the Earth gets the sun-light at one time? Only one-half, because the Earth is round.

What is the time called during which any place is in the Sun-light? Day.

And when it is out of the Sunlight? Night?

If the Earth did not spin round, what would happen? It would always be day on one side of the Earth, and always night on the other.

But since the Earth does spin round? All the parts of it are passing, one after another, into and out of the sun-light; and so day travels round the Earth.

What is sun-rise at any place? The time when that place first comes in sight of the Sun.

In what direction does the Earth spin round? From west to east.

So Sun-rise travels round the Earth? From east to west.

What is the time when a place is just leaving the Sun-light. Sun-set.

What is Noon? The time when the Sun is highest in the heavens, or when a place is right in front of the Sun: also called mid-day.

Days and Hours.—What is the interval between noon to-day and noon to-morrow? A day.

How is a day divided? Into twenty-four equal parts, called hours.

How do we measure time as it passes? By the clock.

What is the end of the first hour after noon? One o'clock.

And the twelfth? Twelve o'clock.

Is the next hour Thirteen o'clock? No.

Why? Because half a day has passed, and it is more convenient to number the hours after mid-night exactly as we numbered the hours after mid-day.

What o'clock is it at noon? Twelve o'clock again.

How is each hour divided? Into sixty minutes.

And each minute? Into sixty seconds.

What do seven days make? A week.

And two weeks? A fortnight.

Pronounce in syllables, and spell, the names of the Days of the Week.

Sun'-day, or Sab'-bath.
Mon'-day
Tues'-day.
Wed-nes'-day (*Wens'day*).
Thurs'-day.
Fri'-day.
Sat'-ur-day.

The Year and Months.—What motion has the Earth besides its spinning motion? An outward motion round the Sun.

How could you show the two motions by means of a top? While it was spinning, I could pass a string round the point and draw it round the table.

How long does the Earth take to make a journey round the Sun? Three hundred and sixty-five days.

What does one such journey make? A Year.

How is the Year divided? Into twelve months.

Pronounce in syllables, and spell, the names of the Months.

Jan'-u-ary.	Ju'-ly,
Feb'-ru-ar-y.	Au'-gust.
March.	Sep'-tem-ber.
A'-pril.	Oc-to'-ber.
May.	No-vem'-ber.
June.	De-cem'-ber.

The Seasons.—What have we seen the spinning motion of the Earth cause? The change from day to night.

What does its onward motion cause? The change of the Seasons.

Which is the warmest season? Summer.

And the coldest? Winter.

What makes the difference between Summer and Winter? In one part of its outward journey, the Earth receives the sunlight more directly on its northern half than on the southern: then the north has summer, and the south winter.

What is the case at the opposite point in the journey? The sun shines more directly on the southern half, and makes it Summer in the South and Winter in the North.

What Season comes between Summer and Winter? Autumn, during which it becomes colder and colder, and the days grow shorter and shorter.

And between Winter and Summer? Spring, during which it becomes warmer and warmer, and the days grow longer and longer.

PRESENTATION.

At the last meeting of the Wentworth Teachers' Association, held on the 22nd ult., Mr. T. C. L. Armstrong, M. A., LL. B., late Modern Language Master of the Hamilton Collegiate Institute, and an active member of the Association, was presented with the following address:—

To T. C. L. Armstrong, Esq., M. A., LL. B.

DEAR SIR,—The severance of your connection with the Hamilton Collegiate Institute, and your entrance into another profession, induce us as members of this Association to request your acceptance of an address expressive of the feelings of respect we have for you as a teacher and as a man.

During your long connection with this

Association the assistance you have rendered us, especially by your thoughtful papers on English Literature and other kindred subjects of Higher English, has proved invaluable to us in our daily labors in the school-room. It is therefore with sincere pleasure that we bear testimony to your skill as a teacher, to your ability as an author, and to the genuine interest you have taken in advancing the interests of the teaching profession.

Your works in connection with the cause of literary culture have brought your name prominently before many who have not the privilege we enjoy,—the pleasure of your personal acquaintance. While we cannot forbear expressing our deep regret that our profession has lost one of its brightest ornaments, we learn with sincere pleasure that your future prospects are of the most promising kind. Permit us then to express the wish that your highest hopes may be realized in your chosen vocation, that you may be long spared to enjoy the reward of your labors, and that though no longer one of us, you may ever look back with pleasant memories upon the time you have spent in our educational institutions.

Signed on behalf of the members of the Wentworth Teachers' Association.

W. H. Ballard, M. A.,
President.

J. G. Carruthers,
Secretary.

J. H. Smith,
P. S. Inspector.

REPLY.

Fellow Teachers.—It is peculiarly grateful to me to receive this token of respect from my old associates in the noble profession of education; but in listening to the eulogistic terms of the address, I feel how far I am from deserving half the praise that has been bestowed on me. At this moment I have all my past failures vividly present to my mind, and I can see that what I once thought was the failure of the pupils was mostly the failure of the teacher. I am happy to know, however, that the methods of instruction are continually improving, owing to the great advancement in the science of education. That science and profession will always have a large place in my thoughts, as indeed a profession dealing in the delights of literature, the deep things of science and the lofty aspirations of philosophy, must have in the minds of all intelligent thinkers. While I am happy to watch the strides in advance made by our educational system, I am not blind to some of its defects and mistakes. Perhaps I might be pardoned a few words on the latter. I consider the system of inspectorship is not the best that could be desired; the area is too large, the amount of good done by the visits of the inspector is at a minimum. Smaller districts would enable the inspector to make more frequent calls on the schools, and thus benefit the teacher by his presence. This would entail a greater outlay on the public schools, but it is only right that they should get it. Our programmes are too extensive and varied, our examinations are too exacting, there is too much tendency to uniformity, at the expense of the individual aptness of the teacher, a tendency that might make our schools into mere machines. I feel, however, that here is not the place to discuss these subjects. I have to thank you sincerely for your very kind address, and beg to assure you that I shall ever entertain the highest regard for the educational subjects, and all honest workers in the cause of education.

EDITORIAL NOTES.

In the last issue of the Magazine we published answers to the questions of the Chemistry Paper set at the last Intermediate Examination, prepared by the Examiner, Dr. Haamel. If the other members of the Central Committee of Examiners would publish model answers to their questions, they would furnish each year a valuable contribution to school literature. They should bear in mind that they are, by means of these Examination Papers, not only testing the work already done, but giving direction and character to subsequent class-room instruction.

Next year will be rendered interesting in the astronomical world by the occurrence of a transit of the planet Venus. This phenomenon can only happen when the planet is at its inferior conjunction, and at the same time very near one of its nodes. It is, therefore, of rare occurrence, but very important, inasmuch as it affords the best means astronomers possess of determining the sun's parallex, and consequently the dimensions of the planetary system. The cost of an astronomical telescope is not very great and the Province of Ontario should have one in connection with the University. Mr. Carpmael, the director of the Meteorological Observatory, is a Fellow of the Royal Astronomical Society and a distinguished graduate of Cambridge University, and is eminently qualified to direct an astronomical observatory. As this is purely an educational undertaking it should be done at the expense of the Province. The Local Government of Quebec supports a well equipped observatory at McGill University; the Colony of Victoria, Australia, has a grand one, while almost every State in the American Union has its well equipped observatory. Ontario has none, and is doing nothing for the advancement of astronomical science. We hope to see the Province placed in a creditable light in this respect before the scientific world.

With the resumption of the scholastic year, we have a resumption of the strenuous exertions of certain head masters to attract students by highly coloured advertisements and elaborate school prospectuses Wood cuts and tinted paper are now at a premium. Imposing edifices rear their classic fronts to the skies. The old royal road to learning has given place to the modern cricket field. A singular harmony is found to exist between conic sections and cheap board. We do not intend to find fault with all such efforts to draw, though it may be that the inducements held out are like the paper on which they appear—*coleur de rose.* We do object, however, to the style of advertising that is practised by one head master who has the effrontery to institute comparisons between his own school and other Collegiate Institutes, of course, to the disparagement of the latter. This contemptible artifice carries with it its own condemnation. With reference to the Intermediate or other Departmental examinations such a course of conduct would seem at best like that of a fortunate speculator taunting his unlucky brethren with their losses. It is also matter for question how far the successes of ex-pupils should be referred to in school records. If these successes are expressly mentioned as those of ex-pupils, very grave objections cannot perhaps be urged against this practice, though even then there should be some limit to it, as will be evident through the recent report of Upper Canada College. Colonel Dennison, after more than a quarter of a century's absence, was marshalled into line with the juveniles and made to contribute glory to the institution from his being awarded the Emperor of Russia's prize for a work on cavalry tactics. On this occasion, the Principal was a better tactician than the Colonel. But when we find the honors and scholarships won by pupils and ex-pupils summed up together in such a way as to convey the impression that all were awarded to pupils direct from the school, we cannot too severely condemn such a deception on the public, and it is to be regretted that any head master should ever have given occasion for making such strictures possible.

GOODWIN'S GREEK GRAMMAR.—*(Ginn & Heath, Boston.)*—For class instruction it has no equal. All the necessary facts and principles of the Greek language are stated and illustrated so *plainly* and *clearly*, yet in so *brief* a compass, that students will find everything easy of comprehension and application, and be relieved from the unnecessary detail found in many school grammars.