THE ELEMENTS OF ACOUSTICS, LIGHT, AND HEAT

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AND

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BY

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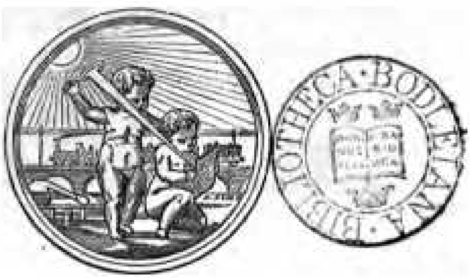

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SYLLABUS

ISSUED BY THE SCIENCE AND ART DEPARTMENT.

ACOUSTICS, LIGHT, AND HEAT.

FIRST STAGE, OR ELEMENTARY COURSE.

Questions will be confined to the following subjects :—

Acoustics.

The pupil ought to have a perfectly clear notion of the manner in which a *wave* is propagated.

He ought to know what is meant by the terms density and elasticity as applied to air and other bodies, and how heat and cold affect the density and elasticity of air.

He ought to be able to describe simple experiments to prove that air possesses both weight and elasticity. He ought to understand the law of Mariotte, the construction and use of the air-pump, and what occurs when a sounding body is placed in a space from which the air has been withdrawn.

He ought to be taught to see the play of elasticity in the propagation of a sonorous wave through air, and to have a clear mental image of the condensation and rarefaction which make up such a wave. He must, of course, be able to distinguish between the motion of a wave and the motion of the particles which at any moment form the wave.

He ought to know how the velocity of a wave is affected by a change of density, by a change of elasticity, or by a change of both.

He ought to know the velocity of sound in air of the freezing temperature, and also the amount of augmentation of velocity for every degree of the thermometer. The temperature of the air being given, he ought to be able to calculate the velocity of sound through it; and the velocity of sound being given, he ought to be able to calculate the temperature of the air.

No doubt or confusion must rest within his mind regarding the meaning of the terms *velocity*, *intensity*, and *amplitude*. He ought also to know the relation of the last two to each other.

He ought to know the laws of the reflection of sound by tubes and mirrors, and to be able to apply his knowledge to the explanation of echoes.

The law of inverse squares, as applied to sound, ought also to be explained to the pupil.

He ought to be able to figure mentally the propagation of a sound-wave through solids and liquids as clearly as through air; to know the velocity of sound through water, and to be able to infer from this the relation of the density of the liquid to its elasticity.

He ought to know how the velocity of sound through air has been determined, and to be well exercised in the calculation of distances by means of light and sound.

The pupil ought to know the physical difference between music and noise, and to be able to state the conditions on which the pitch and the intensity of musical sounds depend. He ought also to be able to describe various methods of producing musical sounds.

He ought to have clear ideas of the *length* of a wave, and of the *time* of a vibration. The length of a wave at a definite temperature being given, he ought to be able to calculate the time of a vibration; and the time of a vibration being given, he ought to be able to calculate the length of the wave.

He ought to be able to describe a method of determining from the pitch of a sound the number of vibrations per second which produce it.

He ought to know the structure of the drum of the ear, including the membranes that close it, and the bones that cross it.

He ought to know the laws of the vibration of strings, and to understand the use of sound-boards in stringed instruments.

He must have a clear idea of the formation of *nodes* upon a string, by the coalescence of direct and reflected waves.

He ought also to know the laws of vibration of columns of air in both stopped and open pipes. The exact condition of the air when the fundamental notes of each class of pipes is sounded, ought to be clearly present in the pupil's mind.

The cause of beats in music ought also to be explained to the pupil, and he ought to know the range of the human ear for musical sounds.

Light.

Before entering upon the subject of light, the teacher will have been careful to make his pupil perfectly familiar with the conception of waves of sound impinging upon the tympanic membrane, and the transmission of the tremor thus produced to the auditory nerve. He need not attempt to enter upon the details of this transference to the nerve, but up to the tympanic membrane, and including it, the idea formed by the pupil of sound-waves and their action must be perfectly distinct. **In all cases an image must exist corresponding to the teacher's words.**

He must understand that the sensation of light is caused by something that hits the optic nerve. That this something, whatever it be, passes through the humours of the eye to reach the nerve behind. The conception of light known as the emission theory can afterwards be made clear to the pupil. According to this theory a ray of light would be a train of these particles.

That a ray of light proceeds in a straight line must be made known to the pupil. In connection with this point the inversion of objects by rays passing through small apertures must be explained.

The mode of determining the velocity of light by the eclipses of Jupiter's satellites must be explained to the pupil.

The law of inverse squares must be illustrated.

The cause of shadows and penumbræ must be explained.

The mode of determining the relative intensities of two lights by means of the "shadow test" must be explained.

The reflection of light from plane mirrors must be explained.

The pupil's attention must be drawn to the lateral inversion of objects by plane mirrors. He must know how the distance of an image behind a looking-glass is affected by a change of position of the glass in a direction perpendicular to its own planes.

The relation between the angular velocity of a reflected ray and the mirror that reflects it must be explained to the pupil. The multiplication of images by angular mirrors ought also to be explained, and also from it the appearance of the kaleidoscope rendered intelligible.

The formation of images by a concave spherical mirror ought to be explained to the pupil. The axis, principal focus, and centre of the mirror are to be pointed out. Beginning with a luminous point placed beyond the centre, and upon the axis, the successive positions of the image of this point during its motion along the axis from a great distance through the centre, through the principal focus, up to the surface of the mirror itself, must be determinable by the pupil. He will then be taught to determine the position of the images of points not placed on the axis. Objects of sensible dimensions, such as the pupil's own body, must then be substituted for points. (The teacher will avail himself of such simple apparatus as he can command in the explanations here referred to; a silver spoon, if he possesses nothing better, will be useful.)

Real and *virtual foci* are to be defined.

The "aberration" of a large spherical mirror must be explained.

The refraction of light must be explained. By means of a simple geometrical construction the meaning of the "index of refraction" may be explained to the pupil without the introduction of the term "sine."

It must be clearly explained that an object looked at with a single eye appears more near the greater the divergence is of the rays which reach the eye from the various points of the object. From this it will be inferred that a lake or river, the bottom of which is visible, appears more shallow than it really is.

Various simple but instructive illustrations of the effects of refraction will occur to the teacher, such, for example, as the rendering of a coin visible by pouring water into a basin, and the apparent bending of a straight stick thrust obliquely into water.

The circumstances under which *total reflection* occurs must be clearly explained to the pupil.

The power and action of lenses must be explained; the teacher will define the *principal focus* of a lens. As in the case of a spherical mirror, he will begin with a luminous point, determining the position and character of its image, while it moves from a great distance up to the lens itself. He will pass from points to objects of sensible dimensions, and show how the position of the image of every point of such object may be determined.

Here also *real* and *virtual foci* are to be explained.

The explanation of the magic lantern is then to be introduced.

It would add much to the efficiency of the instruction if the teacher would illustrate the points here referred to by common spectacle lenses, provided he has nothing better.

The pupil in the first class is also in a condition to know what is meant by the spherical aberration of a lens.

He must understand the optical structure of the eye, be able to give a clear account of the conditions of distinct vision, and of the causes and remedies of long and short sight.

He ought to be acquainted with the fact that impressions persist upon the retina, and to know what is meant by irradiation.

He ought to know the principles of binocular vision, and to clearly comprehend how the impression of solidity is produced by the stereoscope.

He ought to be made acquainted with the composite character of white light; and to be able to describe an experiment by which such light may be resolved into its coloured constituents.

He ought to understand the doctrine of colours as far as they are produced by absorption.

And he ought to understand the meaning of *chromatic aberration*.

Finally, it is to be stated to the pupil that according to our best knowledge the sensation of light is not produced by the impact of little particles darted out from luminous bodies; but that it is caused in a manner somewhat similar to the sensation of sound, namely, by the successive shocks of minute waves against the retina.

Heat.

The pupil should know the general effect of heat upon the volumes of bodies, and should be able to describe experiments illustrative of the expansion of solids by heat. He ought also to have an idea of the almost irresistible force of this expansion.

He ought to understand with perfect clearness what is meant by the *co-efficient of expansion*, linear, superficial, and cubical.

He ought to know by heart the co-efficients of expansion of gold, silver, platinum, iron, and glass; and the reason why it is possible to fuse platinum wire into glass without fracture on cooling.

He ought to know the principle of Breguet's metallic thermometer, and to be made acquainted with some of the precautions which changes of volume by heat and cold render necessary in the arts.

He ought to be able to describe and explain the gridiron pendulum.

He must be able to describe the construction and explain the use of the mercurial thermometer; the scales of Fahrenheit, Celsius, and Reaumur must be known to him, and he must be able to convert immediately the readings of any one of them into those of the others.

The dependence of the boiling point of water upon external pressure ought to be known, and the pupil must be able to give illustrations of this dependence.

He ought to know by heart the co-efficients of expansion of water, alcohol, and mercury.

The pupil must be well acquainted with what is called the *maximum density* of water, to state at what temperature it occurs, and to point out its effects in nature.

He ought to be acquainted with the change of volume which