The Teaching of "Regular" Physics

— PART ONE —

By Jack Smith

PHYSICS, as a secondary school subject, makes a study of the closely related sciences of mechanics, heat, electricity, light, sound, the branches of the sciences devoted to the study of radiations (i.e., X-rays, gamma rays, cosmic rays, etc.), and of atomic structure. That, in the nutshell, are the various study units found in the course.

Where this is not found or recommended, a definite set of minimal requirements should be evolved for the regular course in Physics. Otherwise, teachers would not care at all to touch on the other study units.

The writer will, presently, outline the basic minimum coverage of the subject. In the next issue, fundamental topics will be suggested to introduce the students to the wider implications of Physics, its modern trends and application.

The new and regular high school Physics should include, among other things, the following basic minimum coverage:

1. General physics

(a) Dynamics. Newton's laws of motion. Conservation of momentum. Composition and resolution of coplanar displacements, velocities, momenta, accelerations and forces. Work, power, kinetic and potential energy. Conservation of energy. Motion of a particle in a straight line. Motion under gravity. Uniform motion in a circle. Simple harmonic motion. The simple pendulum. Vibration of a mass at the end of a spring.

(b) Statics and hydrostatics. Moments and couples. Center of gravity. Density. Fluid pressure (center of pressure and metacenter maybe excluded). The mercury and aneroid barometers. Floating bodies and the principle of Archimedes.

(c) General mechanical properties of solids, liquids and gases. Experimental determination of friction between solid surfaces. Determination of coefficient of friction. Elasticity: Elastic limit, Hooke's law, yield point, stretching of a wire, determination of Young's modulus. Surface tension: experimental illustrations; measurement of simple methods; excess pressure inside a spherical bubble; rise in capillary tubes. Boyle's law. Descriptive treatment of kinetic theory.

2. Sound

(a) The nature of sound. General characteristics of wave motion and vibrations. Longitudinal and trasverse waves. Progressive and stationary waves. (The equation for progressive waves is not expected.)

(b) Propagation of sound. Determination of velocity in free air. Effect of temperature and wind on the transmission of sound through the atmosphere. Factors influencing the velocity in air. Reflection of sound. Echoes. Doppler effect.

(c) Production of sound. Loudness, pitch, quality. Vibration of strings, air columns and tuning forks. Overtones. Forced vibrations and resonance. Beats. Determination of frequency by sonometer and velocity of sound by resonance tube.

3. Heat

(a) Thermometry and calorimetry. Temperature; quantity of heat. Liquid in glass thermometers. Calorimetric determinations by the method of mixtures and by electrical heating.

(b) Thermal properties of solids, liquids and gases. Expansion (the determination of the absolute coefficient of expansion of a liquid will demand a knowledge of only simple methods). Ideal gas laws. Absolute temperature. Specific heat. Change of state: latent heat. Saturated and unsaturated vapors. Determination of saturation vapor pressures. Dew point and relative humidity.

(c) Transference of heat. Conduction, convection and radiation. Thermal conductivity and its determination (students should have a knowledge of one simple method for a good solid conductor and one simple method for a bad solid conductor; methods involving emissivity need not be required).

(d) Nature of heat. Heat as a form of energy. Relation between thermal, mechanical and electrical units of energy; determination of this relationship by a mechanical and an electrical method. Conversion of heat into mechanical energy (students should know that while all the work done on a system may become

heat, only a part of the heat energy in a heat engine can be converted into work: only a very elementary treatment is expected).

4. Light

(a) Geometrical optics. Reflection and refraction at plane surfaces. Total internal reflection and associated phenomena. Determination of refractive index for solids and liquids (simple methods employing grazing incidence should be included; refraction at a single spherical surface may be treated). Spherical mirrors. Refraction through a prism. Spectrometer. Dispersion. Deviation by a small-angle prism. Thin lens (full formula). Thin lenses in contact.

(b) Production of light. Visual effects of light, color phenomena. Simple treatment of photometry and spectroscopy (defining the following: international candle, lumen, lux, foot-candle. The cosine law should be included). Emission and absorption spectra.

(c) Optical instruments. Simple treatment of the following: the eye as an optical instrument; spectacles; the telescope and the microscope; the camera (only the principles of these instruments need be studied, as exemplified by the appropriate arrangement of two thin lenses).

(d) Physical optics. Wave and corpuscular theories of light. Reflection and refraction at plane surfaces by Huygens' secondary wavelets. The principles of interference. Young's experiments. Qualitative account of the characteristics of radiations outside the visible range of wave lengths. Electromagnetic spectrum.

5. Electricity and Magnetism

(a) Magnetism. Magnetic field, magnetic moment. Deflection and vibration magnetometers (the determination of M and H by the combined oscillation and deflection methods need not be elaborated). Comparison of fields and magnetic moments. The earth's field, horizontal and vertical components, the compass, the dip circle. Magnetic properties of iron and steel. Intensity of magnetization curves by magnetometer. Elementary treatment of the magnetic properties of the materials employed in permanent magnets, electro-magnets and transformer cores. Descriptive account of dia-, para-, and ferro-magnetism.

(b) Electrostatics. Elementary facts. Force between charges. Unit charge. Intensity, potential, capacity. Electrostatic units of potential and capacity. Capacity of sphere and parallel plate condenser. Effect of dielectric on capacity. Condensers in series and in parallel. Energy of a charged condenser.

(c) Current electricity. Simple experimental demonstrations of the connection between static and current electricity. Magnetic effect of electric current. Force on current-carrying conductor in a magnetic field. Principles of construction and use of moving coil galvanometer, ammeters, voltmeters. Measurement of potential difference, resistance and current. Electro-magnetic and practical units of current, potential difference, resistance and capacity. Field at center of circular coil; the tangent galvanometer. Ohm's law. Heating effects. Electrical energy and power. Resistances in series and parallel. Wheatstone bridge, potentiometer. Use of standard cell and standard resistance.

(d) Electrolysis. Faraday's laws. Descriptive treatment of primary and secondary cells.

(e) Electro-magnetic induction. Faraday's experiments on electro-magnetic induction. Simple experimental phenomena. Elementary principles of A.C. and D.C. generators and D.C. motors. Qualitative treatment of alternating current and transformers.

(f) Electronics. Elementary qualitative treatment of the following: discharge through gases; the electron; conduction by metals and electrolytes; the diode; X-rays; the photo-cell.

Physics has been an interesting school subject to the students in the brighter sections. The advancement of science becomes more difficult to cope with when its study and understanding is limited to but a few learned people. Science teachers arouse the interest and provoke the intelligence of their students into a more serious study of Physics to enable these youths to become advocates of science, either pure or applied. More aptly yet if they could be inspired to become scientists of the Philippines.

There are suggested hereunder some topics which will introduce the students to the wider implications of Physics, its modern trends and applications. The study of these topics will be a veritable foundation for those who intend to pursue the course in college. These study units may supplement the regular course of Physics, the basic minimal coverage of which was delineated in the first part of this feature.

1. **Mechanics and elasticity.** Laws of motion extended to rotation about a fixed axis (details may be set on the theory and use of the compound pendulum). Moments of inertia in simple cases. (Students should be expected to be able to calculate the moment of inertia of a uniform rod about an exis normal to its length: through the center, at one end, of a uniform circular disk about an exis through its center perpendicular to the disk, and of the rim of a flywheel. They should be able to describe the experimental determination of moments of inertia by simple methods.) Stress and strain; definitions of rigidity and bulk moduli of elasticity; work of deformation; torsional oscillations (the mathematical proof of the relation between the torsional couple and the deflec-

tion of a wire and experimental determinations of the bulk and rigidity moduli can be excluded).

2. **Viscosity.** Coefficient of viscosity. Experimental investigation with narrow tubes (the derivation of Poiseuille's formula may not be required). Experimental comparison of viscosities. Simple treatment of orderly and turbulent motion, streamlining, terminal velocity of a falling body.

3. **Gravitation.** The work of Copernicus, Kepler and Newton. Elementary quantitative treatment of circular orbits. The relation between the gravitational constant and gravitational acceleration. Determination of the gravitational constant (details of only one method of determination need be studied). Solar system in outline (the students should be expected to have a knowledge of the following topics, simply treated: characteristics of the major planets; the sun as nearest star, sunspots, eclipses; the moon, its motion, phases and eclipses; tides and their connection with sun and moon).

4. **Thermometry and radiant energy.** Scales of temperature. Principles of thermoelectric and resistance thermometry, and of optical pyrometry, with simple experimental illustrations (practical details of the use of platinum resistance thermometer need not be expected). Heat exchanges by radiation. Stefan's law and a descriptive treatment of the distribution of energy in black-body radiation.

5. **Properties of gases.** Isothermal and adiabatic expansion. Specific heat of gases. Significance of the difference between and the ratio of the principal specific heats of a gas. Pressure-volume relationships for real gases. Critical temperature. Liquefaction of gases. Cooling by evaporation, and its application to a simple refrigerator (Van der Waals' equation is not expected; proof of the equation $PV^{\gamma} = \text{constant}$ need not be required; and a detailed knowledge of the Joule-Thomson effect is not required).

6. **Kinetic theory.** Derivation of expression for pressure exerted by ideal gas; relations between temperature and molecular kinetic energy. Qualitative treatment of the following: the differences between ideal and real gases, evaporation, diffusion, viscosity, Brownian movement. Distinction between solids, liquids and gases.

7. **Meteorological physics.** Elementary treatment of the following: the structure of the atmosphere; vertical and horizontal distribution of temperature and wind (the exponential variation of pressure with height in a homogeneous atmosphere is excluded). Hygrometry. Formation of clouds, fog, dew, and hoar forst. Meteorological optics; elementary treatment of mirage, rainbow, haloes, coronae, color of the sky. Lightning and thunder-storms.

8. **Applied acoustics.** Measurement of frequency by the stroboscopic method. Intensity and loudness levels, decibel, phon. Simple descriptive treatment of phonograph disk, sound film, microphone, loudspeaker. Reverberation and decay of sound in rooms, effect of absorption.

9. **Optical instruments and measurements.** The velocity of light: its determination by one terrestrial method, treated simply. Measurement of illumination. Descriptive treatment of the defects of images formed by thin lenses. Dispersive power. Correction of chromatic aberration. Telescopes and microscopes (students will be expected to give a simple account of real instruments including some knowledge of chromatic aberration and resolving power and, for the microscope, the principles of oil immersion and the optical condenser; details of the eye-pieces are excluded; and reflecting telescopes are included). Projection lantern.

10. **Wave properties of radiation.** Interference phenomena in thin films. Nature of diffraction grating. Elementary treatment of the crystal as a diffraction grating for X-rays (no treatment of half-period zones is required; the treatment of a crystal as an X-ray diffraction grating is confined to a simple study leading to Bragg's law). The production and detection of plane polarized light. Uses of polarized light.

11. **Electro-magnetic induction and alternating current.** Simple treatment of relation between electromotive force and rate of change of magnetic flux. Electromotive force produced in a coil rotating uniformly in a magnetic field. Qualitative treatment of self and mutual induction. Use of search coil and ballistic galvanometer (the theory of the mode of operation may not be discussed). Measurement of alternating current and voltage. Root mean square values. Qualitative treatment of effect of capacitance and inductance in A.C. circuit. Uses of transformers in connection with high-voltage transmission. Use of cathode ray oscillograph in study of A.C. phenomena (intended to illustrate the mathematical form of the wave equations using a linear time base).

12. **Electronic and atomic physics.** Elementary treatment of the triode as detector, amplifier and oscillator. Outline of the simpler applications of the foregoing in radio. The electron. Determination of **e** and **e/m** (the methods of J. J. Thomson and Millikan will be studied). Connection with the specific charge of ions in electrolysis. Simple account of positive rays (only a descriptive account of J. J. Thomson's experiments will be studied). Simple account of radio-activity (details of the changes in chemical nature accompanying disintegration are not required). The atom as nucleus and electrons; relation to atomic weight and atomic number (no experimental methods of determining nuclear charge or atomic weight need be studied).