C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

REPORT ON CANDIDATES' WORK IN THE SECONDARY EDUCATION CERTIFICATE EXAMINATIONS JUNE 2005

PHYSICS

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GENERAL PROFICIENCY EXAMINATION
JUNE 2005

SCHOOL'S REPORT

General Comments

In June 2004 the total number of candidates sitting this year's CSEC Physics exam was 9209 compared with 8042, an increase of 15%. At the same time there has been an across the board increase of approximately 15% in total CSEC registrations this year. The examiners find it most pleasing that Physics, considered by many students to be one of the more difficult subjects, is outpacing the average growth rate across all subjects.

Although we would not wish to claim sole credit for this welcome and pleasing trend, we wish to record the fact that over the years this committee has expended considerable effort in trying to construct examination questions which are grounded in the real-life experiences of students and would therefore make Physics a more appealing subject to a wider range of candidates.

Overall performance in the 2005 Physics CSEC Examination was, in the opinion of the Examiners, quite satisfactory with 61 per cent of candidates achieving between Grades I and III. One commendable feature of this performance was the fact that the performances in both Use of Knowledge sections and the Knowledge and Comprehension sections were similar.

Many of the areas of weakness observed in this year's examinations are the same ones which occur year after year. The examiners wish to make a special plea to principals and heads of science departments to pay special attention to interventions which can correct these weaknesses. Very often the intervention needed requires no additional resources apart from a certain diligence in carrying them out and can yield significant improvement in performance

Paper 01 – Multiple Choice

The performance in this year's multiple choice paper is similar to that of recent years. The average on this paper has remained fairly stable between 33 and 35 (out of a possible 60) over the last 5 years, and this year's average score was of 34 (out of a possible 57) with a standard deviation of 10.2 is very much of the same order.

Editorial note.

In the remainder of this report, the exam questions are broken down to show their correspondence to the Specific Objectives of the Physics syllabus. The Specific Objectives are italicized while the corresponding question sections are shown immediately below in normal type. The performance of candidates on each of these questions in turn is then discussed.

Paper 02 – Structured Questions

Question 1 Data Analysis, Section D – Light and Waves

Candidates were given the tabulated results of an experiment to find the index of refraction of a glass block and were given the following tasks:

(a) Complete a table of values using calculators to obtain the sines of six angles of incidence "i" and the corresponding six angles of refraction "r" .

(b) Use the values obtained to plot a graph of sin *i* against sin *r* on the graph paper provided.

A2.3 express the result of a measurement or calculation to an appropriate number of significant figures or decimal places;

A3.1 plot, interpret and use graphs of experimental data;

A3.2 draw a line of 'best fit' for a set of plotted values;

Candidates were given the following tasks:

(c) Find the slope n of the line drawn in part (b).

(d) State what the slope of the graph represents.

A3.3 determine the gradient and intercept of a straight line graph.

Candidates were given the following tasks:

(e) Draw a labeled diagram identifying the apparatus used and angles measured by the student to obtain the results.

(f) In the experiment on which this question is based, candidates are asked to consider A ray of light incident at an angle of 35 and with the aid of dotted lines on the graph to determine the angle of refraction produced.

D*6.4 describe the refraction of light rays;*

Recall that the passage of a ray of light through a parallel - sided transparent medium may result in lateral displacement of that ray. Draw diagrams.

D6.5 state the laws of refraction and use Snell's Law to solve numerical problems;

Perform an experiment to test Snell's Law.

Performance Overall: The average mark for this question was 16.72 out of a possible 30 and the standard deviation was 7.52. Approximately 6 candidates scored full marks.

Areas of good performance Most students were able to complete the table correctly.

Areas of weak performance Many candidates did not realize that their calculator was in the radian mode rather than the degree mode.

Many candidates appeared to be unfamiliar with the sine function.

Many candidates were not aware that their calculated results should have been given to 3 significant figures.

Some candidates were not able to round off decimals.

Some candidates were unaware that the sine of an angle has no units.

Many candidates had difficulty in choosing a suitable scale and in selecting the correct orientation of the axes.

Many candidates used data from the table to determine the slope of their graph and some of those who used points from the line did not use a large enough triangle.

Part (e) of this question was very poorly done by the majority of candidates.

General comments and recommendations It is surprising that a large number of candidates have not mastered the basic skills tested by the data analysis question despite the fact that these skills are examined year after year.

Teachers need to bring to the attention of their candidates the fact that writing an examination is an exercise in communication and they need to show all the required working in order to obtain maximum marks.

Question 2 Section B - Mechanics

(a) (i) State the principle of conservation of energy

B5.4 state the law of conservation of energy and apply to problems;

(ii) Define the term 'potential energy'

(iii) Give one example of a body possessing potential energy.

B5.6 define potential energy as the energy stored by an object by virtue of its position or state;

(iv) Define the term 'kinetic energy'

(v) Give one example of a body possessing kinetic energy.

B5.7 define kinetic energy as the energy possessed by a body by virtue of its motion;

(b) At a football match between two college teams, the referee ordered a free kick. The ball of mass 1.5 kg was placed at rest. The kick was about to be taken by an eager footballer.
What was the potential energy of the ball just before the kick was taken?

(c) The footballer kicked the ball and it was caught by the opposing goalkeeper, 4 metres above the ground. The ball was travelling at 10 ms^{-1}

(i) Calculate the potential energy of the ball just before it was caught

B5.9 calculate the change in gravitational potential energy using $\Delta E_p = mg\Delta h$;

(ii) Calculate the kinetic energy of the ball just before it was caught.

B5.10 calculate kinetic energies using the expression: $E_K = \frac{1}{2} mv^2$;

(iii) After the ball was caught, what was the kinetic energy converted into?

B5.4 describe the energy transformation(s) in a given situation;

Performance Overall: The average mark for this question was 9.25 out of a possible 15 and the standard deviation was 4.26. Approximately 411 candidates scored full marks.

Areas of good performance:

(a) (iv) and (v) Definition and examples of kinetic energy
(c) (i) and (ii) formulae for calculating kinetic and potential energy.

Areas of weak performance:

(c) (iii) Energy conversions
(a) (ii) Potential energy definition

General comments and recommendations

The vast majority of candidates believed that a body had to be at rest in order to have potential energy. Teachers should try to use imaginative examples to dispel this common misconception.

Many candidates could not state the entire "Principle of Energy Conservation". Most recognized that energy could not be destroyed but for some strange reason they believed that energy could be created.

Many candidates did not know that any number multiplied by zero equals zero.

Question 3. Section C – Thermal Physics

(a) Define the "heat capacity of a substance" and state its SI unit.

C3.1 define heat capacity, 'C';

(b) Name THREE modes of heat transfer

C4.1 explain the transfer of thermal energy by conduction.
C4.2 explain the transfer of thermal energy by convection;
C4.3 explain the transfer of thermal energy by radiation;

(c) A well-insulated hot water tank is used to supply hot water to a residential dwelling house. The immersion heating element inside the tank has a power rating of 2200 W and the tank contains 125 kg water at 28·C. Calculate

(i) the energy supplied by the heating element in 2 hours

B5.11 recall power as energy converted per unit time and use this relationship to solve problems;

$$P = \frac{E}{t}$$

(ii) the heat energy supplied to the water, given that its temperature increases to 58·C

(iii) the heat capacity of the tank, assuming that the tank and the water reach the same final temperature of 58·C.

C3.1 define specific heat capacity, ‘c’;

C3.2 recall $E_H = mcÐθ$ and use it to solve problems on specific heat capacity and heat capacity;

C3.1 define heat capacity, ‘C’;

Performance Overall: The average mark for this question was 7.19 out of a possible 15 and the standard deviation was 4.52 . Approximately 160 candidates scored full marks.

Areas of good performance

The modes of heat transfer.
All the relevant formulae required in this problem.

Areas of weak performance

A large number of candidates were unsure of the distinction between “heat capacity” and “specific heat capacity”.

(c) (iii) calculation of heat capacity.

General comments and recommendations

The examiners recommend that teachers spend some time driving home and distinguishing between the TWO concepts: Specific Heat Capacity and Heat Capacity. It may be useful to recognize that specific heat capacity is a property of a SUBSTANCE (usually homogenous), such as water, copper, rice, aluminium, nitrogen, glass, tin, gold etc. while heat capacity is a property of DISCRETE OBJECTS such as a cup, a concrete block, a given glass vessel, a thermometer, a piece of wire and so on.

Some candidates did not seem to appreciate the difference between a “temperature” and a “temperature difference”. Teachers should make every effort to eliminate these conceptual weaknesses.

Question 4. Section E – Electricity and Magnetism

(a) Explain what is meant by the term ‘magnetic field’.

E6.7 define a magnetic field as the region in which a magnetic force may be exerted;

(b) TWO bar magnets are close to each other so that their magnetic fields interact. Sketch the field pattern for the TWO arrangements shown

(i) Two bar magnets aligned along a straight line so that their N poles are closest to each other.

(ii) Two bar magnets aligned along a straight line so that the N of one is closest to the S pole of the other.

E6.8 *map the magnetic fields;*

(a) around a single strong magnet;
(b) around and between two strong magnets;

(c) Candidates were given a figure showing a transformer in which the primary is connected to a dc battery and a switch while the secondary is connected to a center-zero galvanometer. The following questions were asked:

(i) (ii) Describe and explain what would be observed on the galvanometer when the switch is closed.

(iii) Describe what would be observed on the galvanometer if the switch is subsequently opened.

(iv) Deduce what would be observed on the galvanometer if the battery were replaced by a low frequency a.c. supply.

(v) How would these observations be affected if the number of turns on the transformer were significantly increased?

E7.11. describe simple activities which demonstrate an induced e.m.f. caused by changing magnetic flux;

E7.18. recall that for an ideal transformer, $P_{out} = P_{in}$.

Transformer formulae to solve numerical problems $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

Performance Overall: Performance on this question was the worst in paper 2 and was very much out of keeping with performance on the other questions on this paper. The average mark for this question was 4.62 out of a possible 15 and the standard deviation was 2.65. Approximately 18 candidates scored full marks.

Areas of good performance :

(b) (i) and (b) (ii)

Areas of weak performance

(a) (i) definition of a magnetic field.

(c) (ii) electromagnetic induction and transformer operation

General comments and recommendations

Teachers are encouraged to make every effort to ensure that their candidates know ALL definitions required by the syllabus.

Concerning the weak performance on part (c) (ii): candidates who found this section difficult did not recognize or were not taught that an e.m.f. is induced in a wire **ONLY while it is cutting lines of flux**. The wire will cut lines of flux when there is relative motion between it and a B-field, or when the B-field is changing. The implication of this is that a d-c source of e.m.f. in the primary of a transformer will only produce current in the secondary immediately after it is switched ON or immediately after it is switched OFF.

Question 5. Section E – Electricity and Magnetism

(a) Candidates were given a verbal description of three logic gates and asked to identify each gate and draw its logic symbol.

E5.4 recall the symbols for AND, OR, NOT, NAND, NOR logic gates;

E5.5 state the function of each gate with the aid of truth tables;

(b) Given a simple alarm circuit with three gates, two inputs and two outputs, candidates were required to determine the truth table for one intermediate signal and the two outputs.

Each output was connected to an alarm.

Candidates were also asked to find the state of the outputs given that the logical conditions of the input switches S1 and S2 were associated with certain physical conditions in a motor car as shown in the table below

	ENGINE ON	**ENGINE OFF**	**DOOR OPEN**	**DOOR CLOSED**
SWITCH S1	ON	OFF	ANY STATE	ANY STATE
SWITCH S2	ANY STATE	ANY STATE	ON	OFF

E5.6 analyze circuits involving the combinations of not more than three logic gates. Example, simple alarm circuits.

Performance Overall: Although the overall performance on this question was satisfactory rather than outstanding, yet the performance was remarkable for the large number of candidates who scored full marks. In fact the modal score for this question was 15 marks, the maximum possible. The average mark for this question was 7.66 out of a possible 15 and the standard deviation was 4.58 . Approximately 995 candidates scored full marks.

Areas of good performance:

The majority of candidates knew how to interpret a TRUTH TABLE.

Areas of weak performance

Far too many candidates did not realize that ALL LOGIC GATES (EXCEPT THE NOT GATE) HAVE MORE THAN ONE INPUT.

General comments and recommendations:

Teachers need to identify the difficulties of candidates who are weak in this area and make every effort to help them overcome their difficulties.

Paper 03 – Essay Questions

Question 1. Section E – Electricity and Magnetism

(a) An acetate rod may be charged positively by rubbing it with a dry cloth, whereas a polyethylene rod will be negatively charged if similarly rubbed. Explain why this occurs.

E1.1 explain the charging of objects in terms of properties of negatively charged electrons which are relatively free to move;

Explain with the aid of diagrams if necessary, why it is possible to pick up small bits of paper with either of these charged rods.

E1.3 explain how a charged object can attract objects having zero net charge;

(b) The positively charged acetate rod and the negatively charged polyethylene rod are made to touch each other, causing 3 μA of current to flow from one rod to the other for a period of 4 ms.

Calculate

(i) the amount of charge which flows through the rod
(ii) the number of electrons involved in the current flow.

E2.4 recall the relationship $Q = It$, and apply it to solve simple problems;

(c) (i) A cloud has the charge distribution shown in a given Figure 1,
In your answer booklet sketch the electric field pattern inside the cloud, treating the charge distribution as that for TWO parallel plates.

E1.4 define an electric field as a region in which an electric charge experiences a force of electrical origin and draw the electric fields around point charges and between charged parallel plates;

(ii) If this cloud is directly over a tall building, explain how the distribution of charges in the building's structure will be affected

E1.1 explain the charging of objects in terms of properties of negatively charged electrons which are relatively free to move;

(iii) The air between the cloud and the building breaks down and there is a flash of lightning. Deduce the direction in which the electrons will flow in this lightning bolt.

E2.3 differentiate between electron flow and conventional current;

Popularity: This question was attempted by approximately 53% of the candidates

Performance Overall: The average mark for this question was 8.09 out of a possible 20 and the standard deviation was 5.65. Approximately 23% of the candidates scored full marks.

Areas of good performance:

(a) (ii) Charging by induction.
(b) (ii) Q = It and Q = ne
(c) (i) Electric field pattern between parallel plates.

Areas of weak performance:

(a) (i) Charging by friction
(b) (i) The vast majority of candidates (approx. 90%) lost marks by not converting ms to s and μA to A. Some candidates thought that ms meant minutes.
A significant number of candidates appeared to be unfamiliar with index notation such as 1.6×10^{-19}.

General comments and recommendations

Teachers are encouraged to take note of the areas of weakness and to instruct their candidates in how to avoid these difficulties.

Question 2. Section F – Physics of the Atom

(a) Candidates were given TWO nuclear reactions along with the data for the relevant nuclides:

$$^{212}_{83}Bi \varnothing \; ^{208}_{81}Tl + \; ^{4}_{2}He + Energy$$

$$^{1}_{0}n + \; ^{235}_{92}U \varnothing \; ^{A}_{54}Xe + \; ^{90}_{38}Sr + 3(^{1}_{0}n) + Energy$$

and were asked to:

(i) Calculate the number of neutrons in Bismuth (Bi)
(ii) Determine the atomic mass or nucleon number of Xe

F3.2 *represent and interpret nuclear reactions in the standard form;*

F2.4 *recall and use the relationship*

A = Z + N;
A - nucleon (mass) number
Z - proton (atomic) number,
N - Neutron number

Use of standard notation for representing a nuclide,

$^{A}_{Z}X$ ***for example,*** $^{12}_{6}C$

(iii) Calculate the energy released in EACH nuclear reaction and the ratio of the larger to the smaller. Deduce the recommendation that the engineer will give to the investor.

F4.1 relate the release of energy in a nuclear reaction to a change in mass; Solution of problems using

Einstein's equation $\Delta E = \Delta mc^2$.

Include fission (with radioactivity) and fusion.

(b) Candidates were asked to characterize α, β and γ rays in terms of their

Range in air
Behaviour in an electric field
Types of track in a cloud chamber.

F3.1 recall the nature of the three types of emissions from radioactive substances;
F3.2 describe the appearance of the tracks of radioactive emissions in a cloud chamber;
F3.3 predict the effects of magnetic and electric fields on the motion of α *and* β *particles and* γ *rays;*

Popularity: This question was attempted by approximately 33% of the candidates

Performance Overall: The average mark for this question was 7.91 out of a possible 20 and the standard deviation was 4.27. Approximately 6% of the candidates scored full marks.

Areas of good performance:

(a) (i) A = N + Z

Areas of weak performance:

(a) (iii) Conversion of Δm from mass units to kg.

(b) Range, in air, of the different types of radiation

General comments and recommendations:

Teachers are encouraged to:

(i) Emphasize the difference between "atomic mass number" and "atomic mass".

(ii) Explain conversion using $u = 1.66 \times 10^{-27}$.

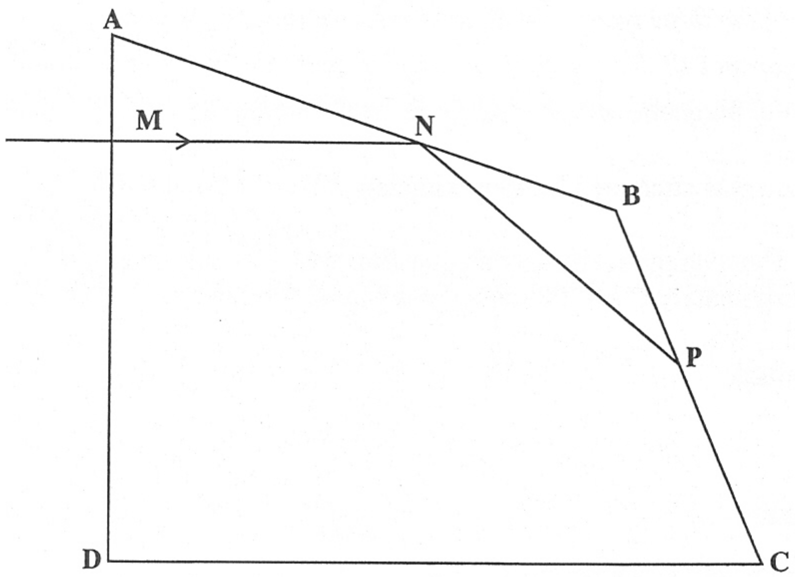
(iii) Distinguish clearly between the types of tracks produced in a cloud chamber by α, β, and γ radiation.

Question 3. Section D – Waves and Light

(a) With the aid of a neat, clearly labelled diagram, describe an experiment to prove the relationship between the angle of incidence, i, and the angle of reflection, r, for a ray of light incident on a plane mirror

D6.1 *state and apply the laws of reflection;*
Use laws to solve problems.
Perform experiments to show the angle of incidence and the angle of reflection are equal.

D5.4 *recall that light travels in straight lines and give examples.*



(b) Candidates were referred to the diagram of an irregular prism as shown above with ray MN incident on the face AD as shown and were asked to:

(i) Show that MN will be totally internally reflected from the face AB.

(ii) Determine the angle θ_m , the angle which the reflected ray makes with the face BC at point P.

(iii) Candidates were asked to redraw the diagram in their answer books and to sketch on their diagrams the ray from point P, showing clearly the path from P through to its emergence from the prism.

Indicate any refraction.

D6.6 *explain with the aid of diagrams what is meant by 'critical angle' and 'total internal reflection';*

D6.7 *calculate critical angles and relate to total internal reflection;*

Popularity: This question was attempted by approximately 54% of the candidates.

Performance Overall: The average mark for this question was 5.57 out of a possible 20 and the standard deviation was 4.91. Approximately 0.5% of the candidates scored full marks.

Areas of good performance

Most candidates were familiar with the experiment but a significant proportion neglected to list the apparatus used.

Areas of weak performance

Some candidates were confused about the difference between reflection and refraction.
Many candidates did not realize that the problem required some elementary geometry for its solution.

General comments and recommendations

Teachers should get their candidates to practice writing out experiments in a structured step-by-step fashion. The examiners were of the opinion that the confusion between reflection and refraction arose largely because of the homophonic relationship between the two words. Teachers are encouraged to note the likely occurrence of this problem and to take steps to avoid it when teaching this topic.

More emphasis should be placed on the teaching of mathematical methods in Physics.

Question 4. Section B – Mechanics

(a) With the aid of a labelled diagram describe an experiment to determine the centre of gravity of an irregularly shaped sheet of cardboard.

B1.8 determine the location of the centre of gravity of a body;
B1.9 Centre of gravity of a variety of regular and irregular shaped solids, including lamina.

(b) Given a labelled diagram of a bicycle on level ground, candidates were required to write the two equations which satisfy the conditions of equilibrium.

(c) Kenny and Candy decided to sit on a see-saw while visiting a local play park. Candy of mass 50 kg, sat 250 cm from the pivot of the seesaw.

(i) Where should Kenny of 60 Kg mass sit so that a state of stable equilibrium exists?
(ii) What should Kenny do if he wanted to elevate Candy.

B1.4 identify situations in which a turning effect on a body will result from the application of a force; Situations that are relevant to everyday life for example, opening a door, a 'seesaw', a spanner.

B1.5 state the principle of moments and use it to solve problems on equilibrium.

Observe situations in which forces are varied to give different equilibrium situations.

Popularity: This was the most popular question on the paper and was attempted by approximately 85% of the candidates

Performance Overall: The average mark for this question was 10.64 out of a possible 20 and the standard deviation was 5.5. Approximately 0.92% of the candidates scored full marks

Areas of good performance:

(a) The standard experiment was known by most candidates.
(c) (i) Was very well done

Areas of weak performance

Very few candidates were able to formulate the equations correctly.

General comments and recommendations

Teachers should get their candidates to practice writing out experiments in a structured step-by-step fashion. The conditions for equilibrium should be expressed in words as well as in algebraic equations.
Teachers should help their candidates appreciate the fact that the Principle of Moments is stated with respect to FORCES and not MASSES.

Question 5. Section C – Thermal Physics

(a) (i) Distinguish between EACH of the following pairs of terms:

(a) Solidification and fusion

(b) Condensation and vaporization

(ii) Describe FULLY the process of sublimation.

C3.5 distinguish amongst solids, liquids and gases;

C3.10 distinguish between evaporation and boiling.

(b) For the changes of state mentioned in (a) and (b) above to take place, energy must be added to or removed from a substance. Give the general name for this type of energy and state what happens to the temperature during these processes.

C3.7 describe a demonstration that shows that temperature remains constant during a phase change;

(c) A student placed 700 g. of water at 28°C in a freezer. After 6 minutes and 15 seconds the water was transformed to ice.

Calculate

(i) the heat energy transferred from the water during the temperature change

C3.3 recall $E_H = mc\Delta\theta$ and use it to solve problems on specific heat capacity and heat capacity;

(iii) the latent heat of solidification, given that 235200 J of heat energy was transferred during the change of state

C3.8 define the specific latent heat and use the relationship
$E_H = ml$ to solve problems on specific latent heat;

(iv) the rate of heat energy transfer for the entire process.

B5.11 recall power as energy converted per unit time and use this relationship to solve problems;

$$P = \frac{E}{t}$$

Popularity: This was the second most popular question on the paper and was attempted by approximately 76% of the candidates

Performance Overall: The average mark for this question was 9.34 out of a possible 20 and the standard deviation was 5.64. Approximately 1.99% of the candidates scored full marks

Areas of good performance:

(a) (ii) Sublimation

Areas of weak performance:

(b) Identifying the general name for the energy involved in phase changes.

General comments and recommendations:

Heat and temperature should be clearly distinguished.
T and t cannot both be used to represent time.
Teachers need to make a clear distinction between thermal fusion and nuclear fusion.

Paper 04 – School Based Assessment (SBA)

Performance by centres in the School Based Assessment was again quite good as a large majority of marks submitted were accepted.

There were still a few areas that teachers have to pay special attention to.

(1) Planning and Design activities should NOT be traditional laboratory activities but should present candidates with a hypothesis that requires investigation. Special attention should be paid in the design of the relevant mark scheme.

(2) Mis-matching of criteria. Teachers should be clear about the criteria for each specific skill being tested.

(3) Breakdown to one (1) of all marks allocated. An example is in Plotting of points :

in Plotting of points :	6 plotted accurately	- 4 marks
	5 plotted accurately	- 3 marks
	4 plotted accurately	- 2 marks
	3 points or less	- 1 mark

(4) All assessments for SBA should have a clear breakdown of marks according to the scheme by skill and criteria. It is tedious to moderate if only a total mark is given per skill.

(5) No mark schemes submitted. Teachers should plan their activities and schemes together. The most accurate moderation takes place if teachers provide an acceptable mark scheme with detailed marking in the laboratory books.

Assistance in the preparation for School Based Assessment in Physics is provided in:

(1) CXC Physics Module #1 - School Based Assessment in Physics.

(2) CXC Physics Syllabus (2002) - pp 62 - 69.