EXAMINERS REPORT

PHYSICS - II

HIGHER SECONDARY SCHOOL CERTIFICATE

ANNUAL EXAMINATION 2018

Compiled By

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PART I: STATISTICAL INFORMATION

The examination comprising a paper of 85 marks was administered to the students who had completed their two years of academic education at Higher Secondary School Certificate (HSSC) level. Question paper was divided into four sections each containing different types of questions, namely: "Section A" consisting of question number one, having seventeen compulsory structured part questions - Multiple Choice Questions (MCQs) of one mark each (20 % weighting); "Section B (chapters 12 to 16) and Section C (Chapters 17 to 21)" each comprising ten open ended questions with limited cognitive demand - Short Response Questions (SRQs) taken from the prescribed book with 49.4 percent weighting and students were required to answer seven out of them of their own choice from each section carrying three marks each; "Section D" consisting of three open ended questions, each of them comprised of three parts, with greater cognitive demand - Extended Response Questions (ERQs) out of which students were required to answer any two questions of thirteen marks each with proportionate weighting of 30.6 percent of the paper. Time duration of the paper was three hours.

A total of 30639 candidates appeared in this paper during the annual examination 2018 and out of them 26656 (87.01 percent) passed the examination with the grade percentage distribution as summarized in Table 1:

Table 1: Grade-wise distribution of candidates

Grade	Students	Percentage of Grade
A1	6816	22.23
A	4749	15.49
B	5445	17.76
C	4687	15.29
D	2722	8.88
E	2170	7.08
F	3971	12.95
Absent	102	0.33
Total	30662	100

PART II: GENERAL COMMENTS

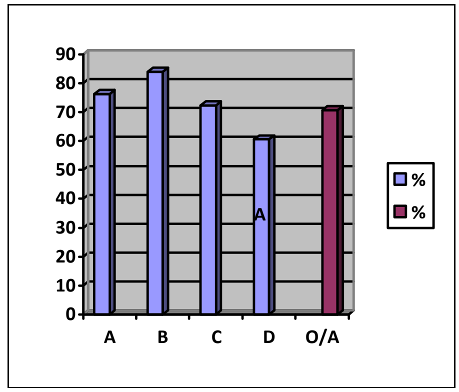
- Most of the students handled "Section A" very well in terms of attainment of relatively better marks when compared with other sections except for "Section B", in which their performance was the best. Generally the questions in this section required mere recall (knowledge level, 76.47 %) of facts, terms, equations and definitions except for part questions 1,3,5 and 6 (version 1836) which required some understanding (comprehension level 23.53 %). The students performed better in knowledge level MCQs while they faced some difficulties in answering part question 3, due to negative statement of the stem and part questions 1 and 5 which required understanding of concepts. However, their performance in part question 6 (understanding level) was good as the correct answer was obvious in the presence of all the three poor distracters. The distracters of part questions 1 and 5 were not appropriately constructed and in each case two of them could easily be ruled out as possible answers. In fact only part question 6 was challenging, which required using of equation for Ohm's law but all three poor distracters of this question made it easy for the students to choose the right option. The students secured on the average 11.70 (68.80 %) marks in this section. The performance of the students in answering the part questions of "Section B", which consisted of four questions 12 (40 %) marks of knowledge, five questions 15 (50 %) marks of understanding and only one part question 3 (10 %) of application levels, was the best when compared with other sections of the paper. They generally faced difficulty in fully answering the questions which involved understanding of concepts, despite the fact that all questions were taken word by word from the questions given at the end of the chapters of the book, which are usually discussed in the classroom by the teacher. The students secured on the average 16.11 (76.72 %) marks in this section. They either did not attempt part question 3 (application level) or partially answered this question. The "Section C" comprising again of SRQs, mostly of mixed cognitive levels in which four questions 12 (40 %) marks were of knowledge, four questions 12 (40 %) marks were of understanding and two questions 6 (20 %) marks were of application levels. The students secured better marks in answering knowledge level questions and generally faced difficulties in answering part questions (i), (ii), (vi) and (vii) which were of understanding level and a very small percentage (around 15 %)

attempted part questions (iii) and (viii), which were of application level and most of the students had left them as choice questions. Since all the questions were taken word by word from end chapter questions of the book which are usually covered in classroom teaching so they managed to secure better marks, however lower than that of "Section A and B". The students secured on the average 13.41 (63.87 %) marks in this section. The "Section D" comprised of three extended response questions (ERQs), each having three parts, however, the part "b" of all questions was not consistent with the topics covered under parts "a and c" and were like SRQs. These questions were of mixed cognitive levels with a bias towards higher cognitive levels. These comprised of three parts of knowledge 8 (20.51 %) marks, five parts 22 (56.41 %) marks of understanding and two parts 9 (23.08 %) marks of application levels. The general performance of students was the lowest in this section mainly due to higher cognitive demands and on the average students secured 13.34 (51.30 %) marks. Out of the three questions, the preference of students varied in selection of questions, 84.4 % attempted Question 4, 59.9 % attempted Question 5 and only 17.2 % attempted Question 6, whereas they were required to select two out of the three questions from this section. The overall question paper comprised of 38.79 % knowledge, 45.69 % understanding and only 15.52 % application level questions (marks). The overall performance of students was good, whose percentage performance index was 70.69 and had secured on the average 61.42 percent marks and almost 87.01 % passed the examination, mainly due to questions of lower level cognitive demands in the question paper, knowledge and understanding level questions. The main factor which contributed towards exaggerated reflected performance is that all questions, even the numerical problems were given word by word from the book, which the students had practiced before in the classrooms and these mere recall (knowledge level) questions for them. The section-wise performance of students is as indicated Fig 1.

Table 2: Accumulative performance.

Section	Performance Index	%
A	0.76	76.20
B	0.84	83.97
C	0.72	72.36
D	0.61	60.61
O/A	0.71	70.69

Fig. 1 Accumulative performance in all sections.

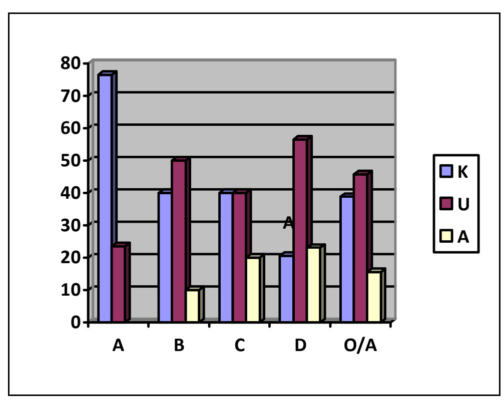


In certain questions where understanding of concepts or their application was required for answering, the students faced some difficulty in comprehending the requirements completely, especially in case of open ended questions contained in sections B and C. In addition, the inappropriate composition and construction of questions including use of ambiguous terms caused hindrance in clarity for understanding the requirements of questions fully by some students whose answers were ambiguous, incomplete or irrelevant. However, in case of recall (knowledge level) questions, they answered better due to their previous knowledge and experience. The overall performance of students varied from section to section, the best in case of "Section B" (SRQs from chapters 12-16), followed by "Section A" (MCQs) and comparatively lower in case of "Section C (SRQs from chapters 17-21)" and the lowest in "Section D" (ERQs). The section-wise marks allocated to different question items according to their cognitive levels are given in fig 2.

Table 3: Marks % - Cognitive Level

Section	Knowledge (K)	Understanding (U)	Application (A)
A	76.47	23.53	-
B	40	50	10
C	40	40	20
D	20.51	56.41	23.08
O/A	38.79	45.69	15.52

Fig.2 Marks % allocated in all sections.



Areas Noted for Improvement of Various Stakeholders

Analysis of question paper, answer scripts, performance and observation/comments of Head and Sub-examiners led to the identification of following deficiencies in the examination system:

Question Paper

i) Inability of paper setter to use appropriate command words while writing the question items for different sections of this paper. In fact some command words lacked the needed clarity to correctly communicate the scope and requirements of the questions, needed to guide the students for answering them. For example, in "Section B" part questions, (i), (v), (vi), (viii) and (ix); in "Section C" part questions, (i), (ii), (v), (vi), (viii) and (ix); in "Section D" the questions 5a, 5b, 6a and 6b.

ii) Inability of paper setter to construct numerical questions where students were required to be tested for the application of concepts (Application Level) to discriminate those who can apply knowledge in novel situations from those who can reproduce through memory only. Numerical problems given in the questions, 2(x), 3(viii), 4b and 5b were reproduced from the book without any change, whereas the only numerical problem, 3(vi) given by making a change in rest mass was constructed non-professionally. This practice leads to the trend of memorizing contents of syllabus including the numerical problems with solutions by the students.

iii) Inability of paper setter to construct challenging MCQs "Section A" in which the students could easily pick up the correct answer without much difficulty as the answers were very obvious and students attained better marks in this section. For example in part questions 1), 2), 3), 7), 8), 9), 12) and 15) two options were obvious to be eliminated as correct answers and in fact students were required to differentiate between the two options left through recall from their memory.

Student Learning Objectives and Examination Grid

iv) The question paper was prepared from the contents of the text book only and the Student Learning Objectives (SLOs) of the course were ignored; even the numerical problems were reproduced. To facilitate the paper setters and the teachers in the institutions, the board had issued the SLOs of the subject and a model question paper which was to be followed in its true letter and spirit including the implied examination grid. The question paper was prepared, following the pattern of the model question paper only, without ensuring the required percentage of question items of different difficulty levels (examination grid). There is a requirement to issue the Examination Grid for this paper to all stakeholders to ensure compliance by all concerned.

Marking Key

v) Marking Key which was issued to the sub-examiners to ensure uniformity in marking of answer scripts by them was sketchy and gave general directions only and hence the award of marks was left to the markers, at their own discretion and understanding. The Marking Key is the backbone of the entire evaluation system and needed to be elaborate explaining the requirements along with award of marks for each completely or partially answered portions of a question. The one and half page Marking Key containing command words, like explanation with formula, definition, correct calculation, correct explanation of each property and etc; reflect that the Marking Key was prepared to meet the examination requirement rather than the purpose for which it is issued. In the presence of such Marking Key the award of marks against the performance of students becomes highly unreliable defeating the very spirit of holding the examinations. The preparation of Marking Key is the responsibility of the Question Paper Setter but here in the instant case it was prepared by the Head Examiner of the marking team.

Markers

vi) The inability of markers to evaluate accurately the answer books is evident from the non-uniformity in award of marks in that, similar answers of different questions were awarded differently, certain incorrect explanations were ignored, incomplete definitions and answers were given full credit. This reflects, incompetence of markers to comprehend fully the requirements of question items, non-professionally prepared question paper and the marking key in addition to disconnect between the question paper setter and the head of marking team who prepared the marking key.

vii) The purpose of examination is twofold; one is to determine the students who have successfully acquired the needed knowledge and skills required at their level and can apply certain concepts in a novel situation and the second one is to place the successful candidates in different grades according to their attainment levels. The substandard question paper, requiring recall of contents as given in the text book, with ambiguously stated requirements and unreliable marking of answer books negate the very purpose of examination and it appears mere an exercise. The examination in its present form will promote rote learning by the students only without testing their comprehension and application skills.

Recommendations

viii) There is a requirement to change existing system of paper setting and marking procedure of answer books at the board level to ensure validity and reliability of the examination. Parameters (question paper pattern and examination grid) be laid down as per international standards of each subject and must be followed for at least five years to ascertain and compare accurately the progress made by the students in teaching and learning in the institutions, against a uniform assessment standard. In the present situation, in the absence of a reliable examination system progress shown through the marks and grades attained by the students remains questionable.

ix) Efforts should be made at the board level to improve quality of question papers in terms of their face, contents, construct and criterion validity through capacity building of test item writers and paper setters.

x) Workshops may be arranged and refresher courses be run for the sub-examiners besides inducted more competent markers available into the system using IT technology.

xi) Efforts of FBISE towards establishment and strengthening of question bank, prepared by the professionals besides continuous additions into it may help to reduce issues of composition and construct of quality question papers. As a start point question papers set by internationally known credible boards during their previous years examinations at HSSC/equivalent levels may be reviewed by a committee of experts of each subject to lay down the guiding principles for preparing the test items.

PART III: QUESTION SPECIFIC COMMENTS

SECTION - A

Question Number One, an exclusive question in this section consisting of 17 compulsory Multiple Choice Questions "(MCQs)" as part or sub-questions was attempted by all (99.7 %) examinees present in the examination halls and the overall achievement of examinees in this section is summarized in Table 2 below:

Table 4: Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 7	8 – 10	11 – 14	15 - 17	Mean (Percentage)
Percentage	2.70	9.81	26.38	25.97	35.13	11.63 (68.42)

Mean marks obtained in this section by the examinees are 11.63 (68.42 %) with an overall achievement of around 76.20 percent which is 4 and 16 percent higher than their overall performance in the succeeding sections "C and D". Overall achievement of 76.20 percent has been highly spatial. Only around 12.51 percent of examinees are positioned in the two lowest quintiles of marks, more than half (52.35 %) in the two median quintiles and approximately more than one third of them (35.13 %) of examinees achieved more than eighty eight percent marks in this section.

Decomposition analysis of part questions revealed that except for four, (part questions 1,3,5 and 6) where students were required to use some understanding of concepts all other thirteen part questions asked were of mere "Knowledge Level", in which students had to recall stated facts, equations and units from the contents given in the book. Those students who were good in memorizing or recalling required information from the contents of the book performed relatively better. Since all questions were compulsory, without negative marking for incorrect answers, so everyone attempted all part questions. Question and response analysis of this section is summarized in Table 3 below:

Table 5: Question and response analysis with option chosen against each question (Version Number 1836)

Question	% A	% B	% C	% D	**Comments** {cognitive level (CL), discrimination index (DI), poor distracter (PD), strong distracter (SD), facility index (FI)				
					CL	DI $_{(0.18)}$	FI	PD	SD
1	23.38	60.69	7.30	8.62	U	0.52	0.61	C,D	A
2	10.62	69.19	18.13	2.06	K	0.51	0.69	A,D	--
3	11.18	6.90	19.28	62.63	U	0.60	0.62	A,B	--
4	4.08	70.11	20.88	4.93	K	0.43	0.70	A,D	--
5	39.06	29.82	27.54	3.58	U	0.69	0.39	D	B,C
6	5.61	3.80	85.79	4.80	U	0.30	0.86	A,B,D	--
7	10.37	4.10	69.42	16.11	K	0.53	0.69	A,B	--
8	14.78	78.10	4.25	2.88	K	0.37	0.78	C,D	--
9	1.33	4.11	3.92	90.64	K	0.16	0.90	A,B,C	--
10	5.43	4.59	2.43	87.55	K	0.22	0.87	A,B,C	--
11	8.71	5.96	76.39	8.95	K	0.42	0.76	A,B,D	--
12	72.26	7.27	6.62	13.85	K	0.54	0.72	B,C	--
13	22.59	64.54	6.90	5.98	K	0.53	0.64	C,D	--
14	16.21	12.07	59.32	12.40	K	0.61	0.59	B,D	--
15	11.44	62.21	18.11	8.25	K	0.56	0.62	A,D	--
16	5.34	6.33	13.63	74.70	K	0.52	0.74	B	--
17	14.42	21.04	51.60	12.95	K	0.64	0.51	--	B

*The correct answer is indicated by shading
Cognitive level: Knowledge (K), Understanding (U), Application (A)

Facility Index (FI): It ranged between 59 and 90 percent in all part questions except for part question 5 and 17 where it was 39 and 51 percent respectively. The facility in part question number 5, involving the direction of forces exerted between two current carrying conductors, proved to be one of the most challenging questions and could hardly be attempted correctly by 39 percent of the examinees. The least challenging question was number 9, regarding mutual induction between two coils, which was attempted correctly by 90 percent of the examinees. FI value for more than eighty eight percent of the questions is more than 0.60 (ranged between 0.59 and 0.90), suggesting that these questions were much easier for this cohort of students. The value of FI for remaining two questions (05 and 17) is 39 and 51 percent respectively, suggesting higher difficulty level. Question 05 involved use of two very strong distracters besides being of understanding level whereas in question 17 the candidates faced difficulty due to lack of preparation despite it being of knowledge level. Generally students leave the last chapter (21) on choice, especially the topic on sub-atomic groups of particles.

Discrimination Index (DI): In order to correlate the performance of the candidates in a sub-question with their overall score (combined 17 sub-questions) discrimination index is calculated by taking 23 percent examinees each from upper and bottom sub-groups of this cohort, keeping in view the sample constraints, four different versions of question papers, in that version 1836 has been taken for analysis as it was attempted by maximum number of students 11845 (38.66 %) , overall higher FI and only 12.51 percent of the candidates are in lower two quintiles (less than 40 percent marks) for this question. The positive value of DI, for all questions, indicates that the requirements of the questions were well understood by the examinees. On the basis of DI values, **thirteen** items are found very good test items for having values equal or more than 0.4, **two** items are reasonably good with DI value ranged from 0.30 to 0.39, **one** is marginal items with DI value ranged from 0.2 to 0.29 and **one** is the weakest (Sub-question 9 with facility index 90 %) with DI value 0.16, (Ebel and Frisbie, 1986). Amongst these, **sixteen** MCQs are found ideal questions having difficulty (facility) index range between 0.3 and 0.7 with DI value greater than 0.24.

Discrimination coefficient measuring effectiveness of each distracter has also been determined using similar formula as suggested by Nitko and Hsu (1984). Accordingly, 23.53 percent of MCQs were found deficient for not having even a single effective distracter and 47.06 MCQs were having only one good distracter. This might be one possible reason for relatively high performance in this section.

SECTION – B (Chapters 12 to 16)

Question number two was the single question in this section consisting of 10 "Short Response Questions (SRQs)" as sub-questions, taken from chapters 12 to 16, and candidates were required to answer any 7 out of them. Most of the candidates attempted all the four of knowledge level questions (i), (iv), (v) and (x), randomly attempted three out of the five understanding level questions (ii), (iii), (vi), (viii) and (ix) and only a small percentage around 20 percent attempted application level part question (vii), in which the direction of current due to mutual induction was required to be given by the candidates. The facility index (FI) of question 2 is 0.95 and its discrimination index (DI) is 0.58. The overall performance of the candidates in this section was very good where they on the average secured 16.11 (76.72 %) marks and 25.66 % out of them secured 100 % marks

Overall achievement of examinees in this section is summarized in Table 4 below:

Table 6 : Distribution of candidates against different levels of achievement

Marks	1 – 4	5 – 8	9 – 13	14 – 17	18 – 21	**Mean (Percentage)**
Percentage	3.23	5.66	14.75	20.74	55.62	16.11 (76.72)

Decomposition analysis of sub-questions revealed that 40 percent questions in this section were of knowledge, 50 percent of understanding and 10 percent of application levels. Those students who were good in conceptual understanding of the subject performed relatively better. Since students had to choose any seven sub-questions out of ten so there was a general trend to select questions requiring lower cognitive demand. Question and response analysis of this section is summarized (most popular "K", on choice "U' and the least attempted "A") in Table 5 below:

Table 7 : Question and response analysis against each sub-question

Sub-question	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Cognitive Level (CL)	K	U	U	K	K	U	A	U	U	K

Question 2
i): (i) Define electric field intensity and give its unit.

This question required the candidates to define electric field intensity as the force per unit charge experienced by a positive test charge placed at a point in an electric field and to give the unit of electric field as Newton per coulomb (N/C) or Volt per meter (V/m).

Question asked was of knowledge level requiring recall of definition of electric field intensity and were also required to give its units. Almost 90 - 95 percent candidates attempted this question. However, some of them were confused and faced difficulty in stating the units of electric field intensity. On the average they secured around 2-2.5 marks.

(ii) What is the role of a material medium if it is placed between the plates of a capacitor?

The question required from the candidates to explain that when a material medium, presumably a dielectric is placed between the plates of a capacitor, then it reduces the intensity of electric field due to its polarization. They were expected to explain that the dielectric medium increases the capacitance of the capacitor by a factor equal to the relative permittivity of the medium (dielectric). They might state, in view of the ambiguity in the type of material medium in the question, the effect of a metal plate (negligible thickness) when placed in between the plates of a capacitor and not touching its plates then its capacity will remain the same as decrease due to two capacitors connected in series is balanced by increase caused due to decrease in the distance between the plates of the capacitor.

Question asked was of understanding level requiring the candidates to explain the effect of a dielectric material placed between the plates of a capacitor. Almost 55 -60 percent candidates attempted this question and successfully gave the equation for the capacitance of the capacitor in terms of relative permittivity of the dielectric. However, about 30-40 percent of them faced some difficulty in correctly giving the reasons of this change in capacitance and the effective surface charge density on the plates. On the average students secured 1 – 1.5 marks.

iii) What are ohmic and non-ohmic devices?

The question asked the candidates to state that in ohmic devices the Ohm's Law is applicable and were required to explain that in such devices opposition to the flow of current always remains constant ($\frac{V}{I}$) *and there is always proportionate increase in current when voltage is increased and were also required to represent the variation of current with voltage graphically. They were expected to explain that the graph is always a straight line, representing a linear relationship between current and the voltage in case of ohmic devices. Candidates were expected to state that these devices are simple resistances (conductors) in case of DC currents when their physical conditions like temperature remain constant. They were further expected to argue that in case of AC, ohmic devices also include inductive and capacitive devices in addition to simple resistances. Candidates were required to state that the non-ohmic devises are those where Ohm's law is* ***inapplicable****, meaning thereby that opposition to the flow of current varies with the change in voltage or the physical conditions like temperature does not remain constant during flow of current. They were expected to show that the graph between voltage and current is not a straight line in case of non-ohmic devices. The candidates were expected to give one example of each Ohmic and Non-ohmic devices.*

Question asked consisted of two parts; one was of **knowledge level** requiring the candidates to recall equation of Ohm's Law and its graphical representation and the second one was of understanding level where they were required to show that differentiation between ohmic and non-ohmic devices is carried out based on the response of current with the change in the applied potential difference. Almost all students (60 - 70 percent) who attempted this question easily recalled the equations and drew the graph correctly for both the devices. However around 25 - 30 percent of them faced some difficulty and vaguely explained the reasons for the non-ohmic devices and did not mention about the ohmic devices in case of AC circuits. Since paper markers ignored this part so the candidates were awarded full marks. The candidates on the average secured 1-1.5 marks.

iv) Write colour codes for carbon resistances in tabular form.

Question required from the candidates to give the colour codes in tabular form as shown.

Colour	*Black*	*Brown*	*Red*	*Orange*	*Yellow*	*Green*	*Blue*	*Violet*	*Gray*	*White*
Values	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*

Question asked was purely recall of numbers assigned to different colours printed on carbon resistances according to internally accepted colour code for interpreting values of resistances (knowledge level) which most of the candidates correctly answered. Almost 90 percent of the candidates attempted this question and on the average secured 2 – 2.5 marks.

v) What is right hand rule in electromagnetism?

The question asked expected the candidates to state that when a magnetic field $\vec{B}$ is applied perpendicular to a current carrying conductor $\vec{L}$ then a force acts on the conductor given by the equation $\vec{F}=I\left(\vec{L}\times\vec{B}\right)$ whose direction is perpendicular to both $\vec{L}$ and $\vec{B}$ and magnitude, $F= ILB$ where I is the current. The candidates were required to explain that the direction of the force can be found easily by applying the Right Hand Rule, in which the direction of current or conductor $\vec{L}$ is along the middle finger and the direction of the magnetic field $\vec{B}$ is along the index finger then the thumb gives the direction of the force. Candidates could express the Right Hand Rule in another way in which when fingers are curled from the direction of current (conductor $\vec{L}$) towards the direction of magnetic field ($\vec{B}$) then the direction of force acting on the conductor will be along the thumb. The candidates could give another easy way of finding direction of the force and is again called the Right Hand Rule stated as that when the middle finger of the right hand points in the direction of the magnetic field, the thumb in the direction of current then the force acting on the conductor will be in the direction normal to palm upwards. The candidates could State the Right Hand Rule in *another situation to find the direction of the magnetic field produced around a current carrying conductor around it in the form of concentric circles which could be stated that when a wire is grasped in fist of the right hand with the thumb pointing in the direction of the current, the fingers of the hand will circle the wire in the direction of the magnetic field produced in the form of concentric circles with their centre at the wire. The candidates in another situation could express the Right Hand Rule to find the direction of magnetic field produced by a solenoid carrying the current when it is held in the right hand with fingers curling around it in the direction of current in the wires then the thumb will point towards the direction of the magnetic field produced by the current passing through the centre of the solenoid.*

Question asked was of knowledge level which required from the candidates to give the Right Hand Rule in case of electromagnetism. Since there was an ambiguity in the question as the Right Hand Rule is used for determining the direction of the force on a current carrying conductor placed in a magnetic field in different situations so a variety of answers were given by the candidates, which all of them were awarded full marks. Almost 85 percent candidates attempted this question who secured on the average 2 – 2.5 marks.

vi) Why should the voltmeter have very high resistance?

Question asked required from the candidates to state that the voltmeter is always connected in parallel to the circuit, connecting the two points between which the potential difference is to be measured. Candidates were required to explain that potential difference shown by the voltmeter is lesser than the actual one due to the current drawn by it and the difference increases with the increase in the current passing through the voltmeter. They were expected to argue the resistance of the voltmeter should be very high so that the measured value of the potential difference is closest to the actual one.

Question asked was of understanding level aimed to test the ability of candidates to explain that when two resistances are connected in parallel to each other the current divides itself into two parts according to the ratio between them with the result, the potential difference shown by the voltmeter is lesser than the actual one and this reduction is dependent upon the resistance of the voltmeter, higher is the resistance lesser is the reduction. This question was attempted by almost 55 - 60 percent of the candidates who secured on the average 1 – 1.5 marks.

vii) What is direction of the current through resistance 'R' in the figure if switch 'S' is; a) closed, b) opened (Diagram).

Question required the candidates to state that there is an induced current in a coil if magnetic flux passing through it changes and this induced current lasts till such time it is changing and becomes zero when it is steady. Further, they were required to state that the *direction of the induced current (magnetic flux) is such that it opposes the change in magnetic flux. Candidates were expected to argue that when the switch is closed the current increases through the primary coil in clock-wise direction and resultantly the magnetic flux through the secondary coil increases which induces a momentary current in the secondary coil in the anti-clockwise direction, from left to right in the resistance R, which reduces to zero as the current in primary coil becomes steady. Further, they were required to explain that when the switch is opened the magnetic flux due to the primary coil in the secondary coil reduces from its maximum steady value to zero which induces a momentary induced current in the clock-wise direction in the secondary coil, from right to left in the resistance R, before becoming equal to zero.*

Question asked was of application level aimed to test ability of the students to apply Lenz's Law in case of mutual induction between two coils in the given situation. The candidates faced difficulty as the diagram in the question paper was not clearly drawn and labeled. In the Marking Key the required direction of induced current through resistance 'R' was mentioned as clock-wise or anti-clock-wise which is incorrect, as it can be from left to right or from right to left. However, this was the least attempted question and around 30 percent candidates attempted this question who on the average secured 0.5 – 1 mark.

viii) Show that ε and $\frac{\Delta\phi}{\Delta t}$ have the same units.

Question required the candidates to state that electromotive force ε and the potential difference are measured in the same units, volt (V) whereas potential difference in volts is the work done in joules per coulomb which is given as, $V = \frac{N\,m}{C}$ =J/C. Candidates were expected to state that $\frac{\Delta\phi}{\Delta t}$ is the rate of change of magnetic flux given by the equation $\frac{\Delta\phi}{\Delta t} = \frac{B\,A}{t}$ and in terms of its units $\frac{\frac{N}{A\,m}\times m^2}{s} = \frac{N\,m}{A\,s} = \frac{N\,m}{(\frac{C}{s})s}$ = J/C= V, the units of the electromotive force ε.

Question asked was of understanding level in which candidates were required to give the units of electromotive force 'ε' and the rate of change of magnetic flux '$\frac{\Delta\phi}{\Delta t}$' by using the equations as per their definitions. They were asked to prove that their units are the same. This question was attempted by almost 70 – 75 percent candidates who on average secured 1.5 – 2 marks.

ix) Define choke. How can it be used?

Question required the candidates to **s***tate that choke or inductor is usually a coil or a solenoid wound from a thick wire so that it has a large value of self inductance and a negligible resistance. They were expected to state that there is a phase difference between AC voltage and AC current passing through the choke, in which voltage leads the current by 90^o or $\frac{\pi}{2}$ and hence there is no dissipation of energy when AC current is passing through the* *choke as its resistance is negligible. Candidates were required to argue that choke is used in electrical circuits for controlling AC without consumption of energy. They were required to explain that since opposition offered by the choke to the AC current is frequency dependent (ωL) so it can be used to block the high frequency AC signals in electronics. Further, they were expected to argue that since choke resists change in the current, by storing energy when current increases and tries to maintain current by using the same stored energy when it is decreasing, so it is used in smoothing circuits in rectifiers.*

Question asked was of understanding level aimed to test ability of the candidates to explain that power dissipation through choke does not takes place as AC current and voltage are out of phase by 90° or $\frac{\pi}{2}$ and were also required to state that choke stores energy in the form of magnetic flux density and utilizes this energy to maintain current through the choke. Around 60 – 65 percent candidates attempted this question and on the average secured 1- 1.5 marks.

x) A sinusoidal current has I_{rms} (effective) value 10A. What is the maximum or peak value?

Question required the candidates to give the relationship between I_{rms} or effective value of a sinusoidal current to its peak value I_o as, $I_{rms} = \frac{I_o}{\sqrt{2}} = 0.707\ I_o$. They were required to calculate the peak value of current I_o by substituting the value of I_{rms}=10A in the equation and after calculation the value comes out as I_o = 14.14 A.

Question asked is of knowledge level in which candidates were required to recall the relationship between root mean square value (I_{rms}) of the AC current and its peak value (I_o). Almost 85 – 90 percent candidates attempted this question who on the average secured 2 – 2.5 marks.

SECTION – C (Chapters 17 to 21)

Question number three was the single question in this section consisting of again 10 "Short Response Questions (SRQs)" as sub-questions, taken from chapters 17 to 21, and candidates were required to answer any 7 out of them. Most of the candidates attempted sub-questions (iv), (v), (ix) and (x) as these were of knowledge level and generally selected the remaining three questions out of sub-questions, (i), (ii), (vi) and (vii) which required understanding of concepts (understanding level) for answering them. The sub-questions, (iii) and (viii) were attempted by the least number of candidates as these were of application level, requiring the candidates to apply their knowledge in the given situations. The candidates secured comparatively better marks in knowledge level questions, requiring mere recall of truth table, definitions and facts from the contents of the text book, followed by understanding level questions and the lowest marks in application level questions, where their answers were partially correct and contained vague and ambiguous explanations. The facility index (FI) of question 3 is 0.84 and its discrimination index (DI) is 0.64. The overall performance of the candidates was lower when compared with sub-questions in "Section B". They on the average secured 13.41 (63.87 %) marks and around 13 percent candidates secured 100 % marks.

Overall achievement of examinees in this section is summarized in Table 4 below:

Table 8 : Distribution of candidates against different levels of achievement

Marks	1 – 4	5 – 8	9 – 13	14 – 17	18 – 21	**Mean (Percentage)**
Percentage	9.86	12.73	21.83	16.91	38.67	13.41 (63.87)

Decomposition analysis of sub-questions revealed that 40 percent questions in this section were of knowledge, 40 percent of understanding and 20 percent of application levels. Those students who were good in conceptual understanding of the subject performed relatively better. Since candidates had to choose any seven sub-questions out of ten so there was a general trend to select questions requiring lower cognitive demand. Question and response analysis of this section is summarized (most popular "K", on choice "U' and the least attempted "A") in Table 5 below:

Table 9 : Question and response analysis against each sub-question

Sub-question	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Cognitive Level (CL)	U	U	A	K	K	U	U	A	K	K

Question 3
i): What is meant by strain energy in deformed materials?

Question required the candidates to state that the strain energy is stored in the material in the form of potential energy by displacing the molecules from their mean positions due to the work done by the deforming force. They were expected to draw a graph between the stretching force and the elongation caused in a wire, which is linear initially and then becomes non-linear. Candidates were required to explain that for the linear portion, the strain energy is given by work done $=\frac{1}{2}l_1f_1$ *where* l_1 *is elongation caused and* f_1 *is the corresponding stretching force. They were also required to explain that the total strain energy is equal to the area under force - elongation curve on the graph. They were expected* *to explain that the strain energy is recoverable in the form of mechanical energy, fully in the linear portion but partially in the non-linear portion as shown on the graph.*

Question asked had two parts; the first one was of knowledge level requiring candidates to state the strain energy stored in the deformed material and the second one was of understanding level where they were required to explain the strain energy stored in the linear and non-linear portions of deformations caused in the material. Generally the candidates remained confined to the linear portion of the deformation only. Almost 60 – 65 percent of the candidates attempted this question who on the average secured 1.5 – 2 marks.

ii) The anode of a diode is 0.2V positive with respect to cathode. Is it forward biased? Explain briefly.

Question required the candidates to state that as anode (P-Side of the diode) is 0.2 V positive compared to cathode (N-Side of the diode) so it is forward biased. They were required to explain that due to diffusion of electrons and holes at the junction of the diode electrons move towards the P-side and holes towards N-side, which creates a potential barrier stopping the further free flow of electrons and holes. Candidates were expected to argue that when external potential difference is applied opposite to the potential barrier, it lowers the barrier and then electrons start to flow from N-side to P-side and holes from P-side towards N-side and hence a current is set up through the diode from P-side to N-side (conventional). Therefore it is forward biased.

Question asked was of understanding level requiring the candidates to explain the potential barrier created at the junction of 'P' and 'N' sides of a diode due to diffusion of electrons and holes at the junction. They were also required to explain that as the anode is positive with respect to cathode so it lowers the potential barrier and hence it is forward biased. Around 65–70 percent candidates attempted this question who on the average secured 1.5 – 2 marks.

iii) Find the gain of the circuit as shown in the figure.(Diagram)

Question required the candidates to state that as the input is being applied to the non-inverting terminal of the Operational Amplifier, as shown in the circuit diagram, so the gain is given by G = $\frac{V_o}{V_{in}}$ *=(1+* $\frac{R_2}{R_1}$ *), where* R_1 *is the resistance between inverting terminal of the amplifier and the ground and* R_2 *is the resistance between output and inverting terminals of the amplifier. They were expected to argue that since* R_1 *in the given circuit is approximately infinity (very large) and* R_2*= 0 so by substituting the values of* R_1 *and* R_2 *the gain G = (1+* $\frac{0}{\infty}$*) =1. Candidates were expected to state that the as the gain G=1, so the output signal will be equal to input without amplification and inversion.*

Question asked was of mixed cognitive levels (knowledge, understanding and application) in which candidates were required to understand from the diagram that input is being applied to non-inverting terminal of the operational amplifier and were required to recall the equation for gain and to calculate the gain in the given situation. This was one of the lowest choice questions attempted by around 35-40 percent of the candidates who on the average secured 0.5-1 mark.

iv) Make Truth table and write Boolean algebraic expression for exclusive OR (XOR) gate.

Question asked the candidates to give the Boolean expression for the output X for the exclusive OR (XOR) gate, which is $X = A\bar{B} + \bar{A}B$*, where A and B are the two inputs. They were required to write the Truth Table as:*

A	*B*	*Output*
0	*0*	*0*
1	*0*	*1*
0	*1*	*1*
1	*1*	*0*

Candidates were expected to state that the output is 1 when the inputs are not identical and it is, 0, if the inputs are identical.

Question asked was of **knowledge level** in which candidates were required to recall the Truth Table and Boolean expression for **exclusive OR (XOR) gate.** This was one of the most popular choice questions attempted by almost 90-95 percent candidates who on the average secured 2.5-3 marks.

v) Define inertial frame of reference. What is non-inertial frame?

Question required the candidates to define inertial frame of reference as that, in which bodies have no linear acceleration, meaning thereby that they are either in a state of rest or move with uniform velocity and they experience no net external force acting on them. Candidates were also required to define non-inertial frame of reference as that, in which bodies are having either acceleration or deceleration, meaning thereby that their velocities are non-uniform when compared with those bodies which are in the inertial frame of reference. These bodies are experiencing a net external force even when they are in a state of rest in the non-inertial frame of reference.

Question asked was of knowledge level in which candidates were required to recall definitions of inertial and non-inertial frames of references. This was again the most popular question which was attempted by 85-90 percent candidates who on the average secured marks 2.5-3 marks.

vi) Find the mass 'm' of an object moving with speed 0.8C if the rest mass is 1kg.

Question required the candidates to state that the mass of a body is a relative quantity and it increases with the increase in its velocity relative to the other bodies at rest in the same frame of reference. They were required to give the equation for the motional mass of the body as $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$, *where* m_0 *is the rest mass of the body and v is the velocity of the body.*

Candidates were required to calculate the mass of the body by using the equation which comes out as m= 1.67 Kg.

The question was of knowledge-cum-understanding level in which candidates were required to recall the equation for motional mass of a body when it is moving with a uniform velocity with respect to an observer and by using it were asked to calculate its motional mass. The mass of the body was given as 1 kg, which is practically unrealistic. The question was attempted by around 60-65 percent candidates who secured on the average 1.5-2 marks.

vii) What are the characteristics of laser light by which it is distinguished from ordinary light?

Question required the candidates to state that the laser light is distinguished from ordinary light, due to the following characteristics, which are:

- *i) It is monochromatic*
- *ii) It is Phase coherent*
- *iii) It is highly directional*
- *iv) It delivers intense energy on a small area as it spreads very less over a long distance.*

Question asked was of understanding level in which candidates were required to give the characteristics of laser light which differentiates it from the ordinary light. This question was attempted by around 65-70 percent of the candidates who on the average secured 1.5-2 marks.

viii) What are the energies in eV of quanta of wavelength λ = 100nm?

Question required the candidates to give the energy of a quanta as E = h υ, where h is the Plank's constant and υ is the frequency of electromagnetic waves, and were expected to express the relation of frequency in terms of wave length and velocity of electromagnetic waves as $\upsilon = \frac{c}{\lambda}$, *where velocity of electromagnetic waves is taken as c=3X*$10^8\ m/s$. *They were asked to calculate frequency by using the given value of wavelength λ = 100X*10^{-9} *m, as υ=3X*$10^{15}s^{-1}$*and by using the value of frequency were required to calculate the quanta of energy as E= 12.4 ev, where h=6.63X*10^{-34}*Js and 1 ev=1.6X*10^{-19}*J.*

Question asked was of application level requiring the candidates to calculate frequency of electromagnetic waves of the given wavelength by using the relation of velocity of light in terms of its frequency and wavelength and then by using Plank's law to calculate the energy of its photon. This was one of the lowest choice questions, attempted by around 45-50 percent candidates who on the average secured 0.5-1 mark.

ix) Define radioactivity.

Question required the candidates to define radioactivity as emission of radiations from the nucleus of atoms of certain elements usually having charge number Z greater than 82. They were required to state that these radiations consist of particles (both charged and neutral) and electromagnetic radiations (highly energetic) and were expected to explain that the particles are both positive (protons, helium nuclei and heavier particles), negative (electrons) and neutral (neutrons etc). They were expected to state that these radiations are invisible and can be detected from the effects they create on the photographic, GM Counter etc.

Question asked was of knowledge level requiring from the candidates to recall the definition of radioactivity and to state different types of radiations along with their important characteristics which differentiate them from the normal ones. This was one of the popular choice questions and was attempted by over 85-90 percent candidates who on the average secured 2.5-3 marks.

x) A particle which produces more ionization is less penetrating. Why?

Question required the candidates to state that the nuclear radiation are highly energetic and can cause ionization by supplying ionization energy to the atoms and molecules of the material through which they pass. They were required to explain that during the ionization process these radiations keep losing their energy as they penetrate till a stage is reached when they cannot ionize further and are absorbed. Candidates were expected to argue that those radiations which cause more ionization as they penetrate lose their energy at a faster rate and hence they have lesser penetration, as in case of α-Particles.

Question asked was of knowledge level which required the candidates to state that when a particle ionizes the other particles, of the matter as it penetrates through it, loses its energy by transferring it to the other particles of the matter. The particle stops further penetration when it is no more capable of ionizing the particles of the matter. This was again a very popular choice question which was attempted by almost by 90-95 percent candidates who on the average secured 2.5-3 marks.

SECTION - D

This section was comprised of three "Extended Response Questions (ERQs)" with equal (13) marks each and candidates were required to attempt any two out of the given three questions. Each question consisted of three parts of mixed cognitive levels, in that 8 (20.51 %) marks part questions were of knowledge level, 22 (56.41 %) marks part questions were of understanding level and 9 (23.08 %) marks part questions were of application level. The overall achievement of the candidates in this section has been the lowest among all sections and they on the average secured 13.34 (51.30 %) marks, which is mainly due to the bias of questions towards higher cognitive levels (understanding and application levels). Though all the questions were taken verbatim from the text book, which are usually covered in classroom teaching, yet performance of students varied from question to question according to their cognitive levels. Approximately, a total of 71.32 percent examinees succeeded in attempting two required questions from this section. Out of them around 53.68 percent attempted questions 4&5, 12.39 percent attempted questions 4&6 and only 5.24 percent attempted questions 5&6. Approximately around 14.12 percent candidates secured 100 percent marks in this section. Overall achievement of examinees in this section is summarized in Table 4 below:

Table 10 : Distribution of candidates against different levels of achievement

Marks	1 – 5	6 – 10	11 – 16	17 – 21	22 – 26	**Mean (Percentage)**
Percentage	15.86	21.32	27.76	14.04	21.03	10.84 (41.68)

Decomposition analysis of questions and their parts revealed that a total of 8 (20.51%) marks questions in this section were of knowledge, 22 (56.41%) marks questions were of understanding and 9 (23.08%) marks questions were of application levels. Those students who were good in conceptual understanding of the subject performed relatively better. Since candidates had to choose any two out of the three given questions so there was a general trend to select questions requiring lower cognitive demand. Question and response analysis of this section is summarized in the table below:

Table 11 : Question-wise Marks & % - Section D

Question	4	5	6	D
Cognition Level	K = 23.08 % U = 46.15 % A = 30.77 %	K = 23.08 % U = 38.46.15 % A = 38.46 %	K = 15.38 % U = 84.62 % A = - %	K = 20.51 % U = 56.41 % A = 23.08 %
Average Marks (Percentage)	8.50 (65.36 %)	7.21 (55.48 %)	6.29 (48.35 %)	13.34 (51.30 %)
Facility Index (FI)	0.79	0.66	0.60	0.69
Discrimination Index (DI)	0.49	0.50	0.56	0.91

Facility Index (FI): It ranged from 0.60 to 0.79 in all questions. Facility index of question number 6, involving the production of laser light, laser action in He-Ne Laser, fusion reaction in the sun and postulates of special theory of relativity was the lowest 0.6. FI above 0.60 suggest that the candidates performed extremely well in all the questions of this section.

Discrimination Index (DI): In order to correlate the performance of the candidates in questions (4-6) of "Section D" with their overall score (in questions 2-6) discrimination index is calculated by taking 27 percent examinees each from upper and bottom sub-groups of this cohort, keeping in view the sample constraints, results of question 1 ("Section A") and questions (2-6) received from two different sources and overall higher FI. The positive value of DI, for all questions, indicates that the requirements of the questions were well understood by the examinees. On the basis of DI values all questions are found very good test items for having values equal or more than 0.4. The DI value of combined "Section D" is 0.91, due to three reasons; first one is that the score of Question 1, was excluded from the overall score as it was received from a different source other than that from whom score of other questions was received, the second one is that the overall higher facility indices of Questions (2 & 3) are (0.95 & 0.84) and their discrimination indices (0.58 & 0.64) and third one was that the combined contribution of the score of "Section D" was 40 percent of the overall score used for calculations.

Specific Responses to Questions – Section D.

Q4.

a. State and explain Ampere's Law. Find field due to current carrying solenoid by applying Ampere's Law.
b. The turns ratios of a step up transformer is 50. A current of 20A is passed through its primary coil at 220 Volts. Obtain the value of the voltage and current in secondary coil assuming transformer to be ideal one.
c. How can colour bands for carbon resistances be interpreted?

Specific Response to Question 4

This question comprised of three parts;

In part a, the candidates were required to state the Ampere's Law, as the sum of scalar products of the magnetic flux density ***B*** *and small vector elements* Δ***L*** *taken around a closed loop, divided into small elements, is equal to the* μ_0 *times the total current enclosed by the loop* $\sum B.\Delta \boldsymbol{L} = \mu_0 I$. *They were required to explain that the Amperean path is a closed loop having any shape and size however it should be such that which makes calculations easier. They were also required to explain that the current carrying conductors which are enclosed inside the loop contribute towards the scalar product* $\sum B.\Delta \boldsymbol{L}$ *only, whereas for those which* *lie outside the loop it is cancelled out. Further, it was expected that the candidates will explain that it is the net current which is taken, as the currents which flow in the opposite directions cancel the contribution of each other and were also expected to explain that the direction of magnetic flux density due to net current is determined by the Right Hand rule.*

In part b, the candidates were required to solve a numerical problem in which they were to give the formula for the ratio of the voltages in terms of turns ratio for a step-up transformer as $\frac{N_s}{N_p} = \frac{V_s}{V_p}$*, where turns ratio* $r = \frac{N_s}{N_p}$*. They were required to calculate the value of output voltage* V_s *by substituting values of r = 50 and* $V_p = 220\ V$ *in the equation* $V_s = r\ V_p$ *which comes out as* V_s*=11000 V. They were also required to give the relationship between input and output powers for an ideal amplifier as Input power = Output power, so* $I_p\ V_p = I_s\ V_s$ *and after substituting the values of current in the primary coil,* $I_p = 20\ A$*, voltage applied to the primary coil,* $V_p = 220\ V$ *and calculated value of output voltage,* V_s*=11000V in the equation, calculated the value of the current in the secondary coil,* $I_s = I_p \frac{V_p}{V_s} = 0.4\ A$.

In part c, the candidates were required to state that the colour bands, usually four, are printed on a carbon resistance, which contain information regarding its value and tolerance according to an internationally accepted colour code, in which each colour has been assigned a specific value and bands are read according to their values from left to right. The first two bands give the first two digits and the third band gives power of 10 with which the value of first two digits is multiplied or it gives the number of zeros which are to be added to the right of the first two digits. They were also required to state that the fourth band is either golden or silver and sometimes there is no band, which gives tolerance of the resistance and is interpreted as; if it is golden then tolerance is $\pm 5\%$*, if silver it is* $\pm 10\%$ *and if no band then it is* $\pm 20\%$.

Question asked was of mixed cognitive levels (knowledge, understanding and application) and was attempted by around 84.4 percent of the candidates. It consisted of three parts; the first part was of understanding level which required the candidates to state Ampere's Law and to explain the importance of the shape of Amperean path in the solution of the problems. Further, it was expected to explain the importance of directions of the currents enclosed inside the Amperean path along with their magnitudes. Most of the candidates correctly stated the Ampere's law and the Amperean path but were vague in explaining the considerations for choosing a particular shaped closed path. Majority of them did not explain the importance of the directions of currents when more than one current carrying conductor are enclosed in the loop and since this was ignored by the paper markers so they were not penalized. In the second part candidates were given a numerical problem in which they required to calculate the voltage and current through the secondary coils of a given step-up transformer in the ideal conditions, which majority of the candidates solved correctly except for around 10 percent who remained confused and irrelevant in solving the numerical problem. The third part of the question was of knowledge level requiring the candidates to recall the procedure of interpretation of value and tolerance from the different colour bands printed in a sequence on the carbon resistances according to internationally accepted system. Majority of the candidates reproduced the interpretation correctly. However, some of them (around 20 %) had an ambiguous idea of interpreting tolerance and since this was ignored by the paper markers so they were not penalized. This was the most popular choice question from this section which was attempted by almost 84.4 percent candidates who on average secured 8.50 (65.36%) marks and around 21.19 percent out of them secured full (100%) marks in this question.

Table 12 : Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 - 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	9.01	17.39	12.25	20.24	41.11	8.50 (65.36)

Q5.

a. Define and explain Coulomb' Law with the help of a figure. Find electric potential at a point due to a point charge.
b. Calculate the gain of non-inverting op-amplifier shown in the figure. (Diagram).
c. Briefly explain the concept of virtual ground.

This question comprised of three parts;

In part a, the candidates were required to state the Coulomb's Law according to which there is a force of attraction or repulsion between two point charges which is directly proportional to the product of their charges and inversely proportional to the square of the distance between them and it acts along the line joining the point charges. They were asked to draw a diagram to explain the Coulomb's Law and were required to give the equation for force between two point charges placed in air or vacuum as $\vec{F} = \frac{q_1 q_2}{4\pi \epsilon_0 r^2}\hat{r}$*, where* $\hat{r}$ *is a unit vector along* $\vec{r}$*. They were expected to state that* ***i****n case of dielectric medium Coulomb's Law is modified as* $\vec{F} = \frac{q_1 q_2}{4\pi \epsilon_r \epsilon_0 r^2}\hat{r}$*, where* ϵ_r *is the relative permittivity of the medium.*

Candidates were also required to state that electric potential at a point in an electric field due to a point charge is the amount of work done per unit charge in bringing a test charge from infinity to that point. They were required to calculate the work done per unit charge in bringing it against the electric field from a point B to point A. In that they were expected to calculate the magnitude of average electric field between A and B as $E = \frac{q}{4\pi \epsilon_0 r_A\, r_B}$ *and hence the work done in moving a unit positive charge from B to A against the electric field which is equal to the potential difference between A and B,* $V_A - V_B = -\frac{q}{4\pi \epsilon_0 r_A\, r_B}(r_A - r_B)$ *or* $V_A - V_B = \frac{q}{4\pi \epsilon_0}(\frac{1}{r_A} - \frac{1}{r_B})$ *. Candidates were expected to calculate the potential at the point A, which is equal to the work done from* ∞ *to A,* $V_A = \frac{q}{4\pi \epsilon_0}(\frac{1}{r_A} - \frac{1}{\infty}) = \frac{q}{4\pi \epsilon_0 r_A}$ *and were required to give a relationship of potential at a point* ***r which is distance*** *from the point charge* ***and lies*** *inside the electric field as,* $V = \frac{q}{4\pi \epsilon_0\, r}$ *.*

In part b, candidates were required to explain that the potential on the non-inverting terminal, on which the input V_{in} *is applied as per the diagram, and the inverting terminal are approximately equal due to high open loop gain of the operational amplifier. They were also required to give the equation for gain of operational amplifier as it is being used as non-inverting amplifier as per the diagram, Gain = (1+* $\frac{R_2}{R_1}$*), and were required to calculate Gain by substituting the values of resistance from the given diagram which are,* $R_1 = 10\ K\Omega$ *and* $R_1 = 40\ K\Omega$*, so Gain = 5.*

In part c, candidates were required to state that the virtual ground is a concept used for circuit analysis in which the voltage is taken as approximately zero (ground) for calculation purposes whereas the terminal is not physically connected to ground. They were required to explain that virtual ground as opposed to actual ground cannot be used as an infinite sink for current. Candidates were expected to state that when operational amplifier is used as inverting amplifier the resistance between non-inverting and inverting terminals is taken very high, approximately infinity, due to which there is no voltage drop between the two terminals (-) to (+) and were expected to explain that as non-inverting terminal is connected to ground so the inverting terminal is also considered to be connected to the ground (virtual ground), zero potential, as the voltages on the two terminals is the same (0V) so both are taken to be connected to ground for calculation purposes.

Question asked was of mixed cognitive (knowledge, understanding and application**)** levels with an equal bias (38.46 %) towards understanding and application levels which was attempted by almost 59.88 percent of the candidates. This question consisted of three parts; the first part was of knowledge-cum-understanding level in which majority of the candidates correctly stated and explained the Coulomb's Law with help of a diagram whereas, only a few around 15 percent of them gave the modified form of the equation of the Coulomb's Law when the medium is a dielectric instead air or vacuum and since paper markers ignored this aspect so the candidates were not penalized. However, around 25 percent candidates faced difficulty in finding the electric potential due to a point charge. Some of them vaguely defined the electric potential and their derivations of the equation were incorrect or irrelevant. The second part was of application level in which candidates were required to calculate the gain of non-inverting operational amplifier given in the diagram, which was partially answered by almost 40 percent of the candidates who attempted this question and since it was taken from the text book so they were able to secure better marks. The third part was of understanding level which required the candidates to explain the concept of virtual ground and majority of them gave irrelevant, ambiguous and vague answers. The overall performance of the candidates in this question was lower, when compared with question 4 included in the same section, who on the average secured 7.21 (55.48) marks and around 14.27 percent out of them secured full (100%) marks in this question.

Table 13: Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 - 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	15.61	25.08	11.04	20.18	28.09	7.21 (55.48)

Q6.

a. Discuss and explain the production of LASER light with the help of figure. Explain laser action in He-Ne laser.
b. Discuss and explain nuclear reaction in the sun.
c. Write postulates of special theory of relativity.

In part a, the candidates were asked to draw the diagram and to explain the stimulated emission of radiations for three level or four level lasers. They were required to explain the concept of meta-stable states in the excited atoms, as these are the excited energy states where the electrons reside for a longer time (approximately 10^{-3} S) as compared to normal excited energy states (approximately 10^{-8} S). Candidates were expected to explain the concept of population inversion, which is caused by the light pump which excites the atoms to energy level higher than the meta-stable state and electrons after spontaneous emission of radiations fall into the meta-stable state where they stay for a longer period of time and candidates were also required to state the population inversion as a state of material when majority of its atoms are excited to the meta-stable state, electrons in atoms at higher energy state. They were required to state that there are two mirrors, one fully and the other one partially reflecting, are attached at both ends of the laser tube for increasing the intensity of laser light through multiple stimulated emission of radiations. Candidates were expected to state that these radiations are emitted out through the partially reflecting mirror. Candidates were also asked to explain the Helium Neon laser, which comprised of two gases Helium (85%) and Neon (15%) and are enclosed in a gas discharge tube. Candidates were required to state that these gases are having nearly identical meta-stable states Helium (20.61 ev) and Neon (20.66 ev). They were required to explain that Neon is the lasing or active medium in the gas discharge tube and some of the atoms of the Helium gas which are excited by high voltage electric discharge excite the atoms of neon to meta-stable state through collision by transferring their own energy 20.61 ev due to de-excitation besides 0.05 ev in form of their kinetic energy and this process causes population inversion in the neon gas atoms with energy 20.66 ev relative to its ground level energy of 18.70 ev. Candidates were expected to explain that spontaneous emission of radiations in some of the Neon gas atoms initiate the lasing action followed by stimulated emission causing the electrons in the neon atoms to drop from their 20.66 ev level to 18.70 ev level emitting red coloured laser radiations having wavelength 632.8 nm and photon energy of 1.96 ev.

In part b, candidates were required to state that the Sun is composed of hydrogen, a small percentage of helium besides a very small quantity of heavy elements and the temperature of core of the Sun is about 20 million degrees Celsius and that of its surface is 6000 degrees Celsius. They were expected to argue that fusion reaction is taking place, as the needed conditions for it are being met, in which hydrogen is being converted into helium. They were required to state that due to this process Sun is maintaining its temperature besides radiating heat energy around it. They were required to give the possible P-P reaction, $^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}H + {}^{0}_{-1}e$ *+ energy, in which protons (Nuclei of hydrogen atom) fuse together to form deuterium*

and in turn deuterium nuclei formed fuse with proton to form helium nuclei $^{3}_{2}He$ *through reaction as given,* $^{1}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + \Upsilon$ *+ energy. They were also expected to state that in the last stage two nuclei of helium* $^{3}_{2}He$ *fuse together as* $^{3}_{2}He + ^{3}_{2}He \rightarrow ^{4}_{2}He + ^{1}_{1}H \;\; ^{1}_{1}H +$ *energy. They were expected to summarize the reaction by stating that in this reaction six protons take part and form one nucleus of helium and two protons besides, 25.7 Mev energy which is 6.4 Mev energy per nucleon.*
In part c, candidates were asked to give the two postulates of theory of special relativity as;

1) *Principle of relativity*
2) *Invariance of velocity of light c*

They were required to state briefly the two postulates, in that; 1) according to first postulate, the laws of physics are the same in all inertial frames of reference and 2) according to second postulate the speed of light remains the same c in empty space in all inertial frames of reference, meaning thereby that regardless of the relative motion of the observer and the source emitting light, the measured value of speed of light c with which it propagates through empty space remains constant.

Question asked was of **knowledge-cum-understanding** level with a bias towards understanding level (84.62%) which was attempted by only 17.16 percent of the candidates. This question consisted of three parts; the first part was of understanding level where candidates were required to discuss and explain the production of LASER light and the laser action in case of He-Ne laser. This part carried 7 (53.85%) marks of this question in which majority of the candidates partially discussed the LASER light and had ambiguous understanding of its production process and vaguely discussed laser action in the case of He-Ne laser. The second part, which required the candidates to explain the nuclear reaction in the sun, they had the idea that fusion reaction is continuously taking place in the sun in which hydrogen gas is converting into helium gas but had partial information about the sequence in which reaction is taking place. The third part was of knowledge level carrying only 2 (15.38%) marks which asked the candidates to write the two postulates of special theory of relativity which was answered correctly by majority of the candidates. This was a least choice question in which candidates secured the lowest marks, not only in this section but also in the entire paper, which are on the average 6.29 (48.35%) marks and around 8.17 percent of candidates had secured full (100%) marks in this question.

Table 14 : Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 - 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	30.62	25.68	16.34	19.84	17.51	6.29 (48.35)

Summary

The higher facility and discrimination indices suggest that the paper was reasonably good and students performed extremely well in answering the questions. However, since all questions were given from the prescribed book so the students who had spent more time in preparation performed better in all the questions. The positive higher value of discrimination index reflects that those students who are overall in upper bracket performed better in all questions. Further, as the questions were given from the prescribed book, which are covered in classroom teaching as a routine so the students had to mere recall them (knowledge level). The question-wise examinees falling in different quintiles are given in the figure 3 and percentage of those securing 100 percent marks in each question are given in figure 4 below:

Fig. 3 Question-wise Quartile Distribution of Examinees

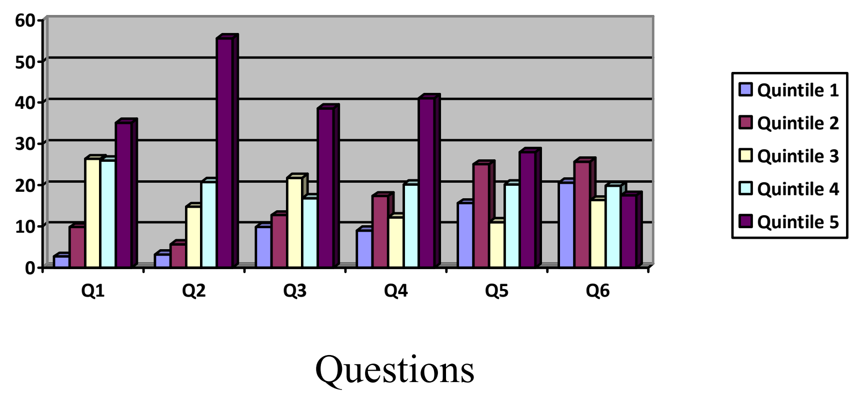


Figure 4 Question-wise percentage of candidates securing full (100%) marks.