EXAMINERS REPORT

PHYSICS - I

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 first academic year of 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 with 20 percent weighting; "Section B (chapters 1 to 6) and Section C (Chapters 7 to 11)" each comprising ten open ended questions with limited cognitive demand - Short Response Questions (SRQs) taken from the prescribed book with 50 percent weighting and students were required to answer any seven 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 percent of the paper. Time duration of the paper was three hours.

A total of 19461 students appeared in this paper during the annual examination 2018 and out of them 15453 (79.40 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	5081	26.11
A	3754	19.29
B	2771	14.24
C	1849	9.50
D	1183	6.08
E	1356	6.97
F	3437	17.66
Absent	29	0.15
Total	19461	100

PART II: GENERAL COMMENTS

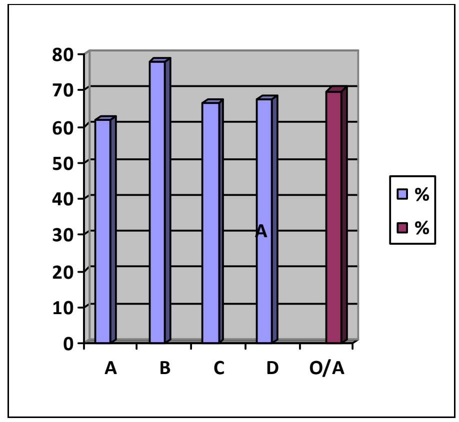
The "Section A" was attempted by almost 99.93 percent of the candidates and their overall performance was the lowest when compared with other sections. This section comprised of MCQs and four different versions of the question papers were given to the candidates with changed order of the part questions. Question Paper version (1836) has been selected for analysis purposes as 6157 (31.64 %) of the candidates appeared in this version of the paper. The question paper comprised of 9 (52.94 %) part questions of knowledge level requiring mere recall of facts, terms, equations and definitions and 8 (47.06 %) part questions were of understanding level requiring clarity of concepts for answering. The students performed better in knowledge level MCQs while they faced some difficulties in answering part questions requiring understanding of concepts and also due to lack of preparation, particularly part question 8, regarding Angular Motion (generally not well prepared) and part question 9 where correct option (pressure) was missing. Candidates also faced difficulties where distracters were strong (part question 14) and could easily answer questions requiring understanding of concepts where distracters were poor (part question 6). The candidates secured on the average 9.63 (56.63 %) marks in this section. The "Section B" comprised of ten open ended sub-questions (SRQs) requiring limited cognitive demand of mixed cognitive levels, out of which one (10 %) of knowledge, six (60 %) were of understanding and three (30 %) of application levels. Almost 96.41 percent candidates attempted this question and their overall performance was the best when compared with other sections of the paper. However, within the section their performance was lower in case of application level questions when compared with those of understanding level. Since all the questions were taken word by word from the book which are usually discussed in the classrooms by the teachers so the students have performed better and they secured on the average 14.82 (70.57 %) marks in this section. The "Section C" comprising again of SRQs, mostly of mixed cognitive levels in which two questions 6 (20 %) marks were of knowledge, seven questions 21 (70 %) marks of understanding and only one question of 3 (10 %) marks was of application levels. They secured better marks in answering sub-questions of knowledge level and generally faced difficulties in answering the understanding and application level questions. Further, it appeared that their preparation for examination was selective as part questions taken from chapters on

Optics and Thermodynamics were attempted by comparatively lesser percentage of candidates and the sub-question (vi) from Optics Chapter of application level was attempted by the least number of candidates (around 25 %). 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 B and D". Almost 89.45 percent candidates attempted this section who on the average secured 12.21 (58.17 %) marks. The "Section D" comprised of three extended response questions (ERQs), each having three parts, however, the part "b" of all questions were inconsistent with the topics covered under parts "a and c" and were like SRQs but with a greater cognitive demand. These questions were of mixed cognitive levels with a bias towards higher cognitive levels. These comprised of three parts 8 (20.51 %) marks of knowledge, five parts 22 (56.41 %) marks of understanding and two parts 9 (23.08 %) marks of application levels. The general performance of candidates was lower in this section when compared with sections "B and C" mainly due to higher cognitive demands and candidates on the average secured 15.14 (58.24 %) marks. Out of the three questions, the preference of students varied in selection of questions, 89.42 % attempted Question 4, 55.07 % attempted Question 5 and only 33.33 % attempted Question 6, whereas they were required to select two out of the three questions from this section. The selection of combination of questions also varied 49.33 percent selected questions (4&5), 28.44 percent questions (4&6) and only 4 percent selected questions (5&6). In addition, around 18.22 percent candidates attempted one question only from this section. The overall question paper comprised of 19.83 % knowledge, 62.07 % understanding and only 18.10 % application level questions (marks). The overall performance of students was good, whose percentage performance index was 69.90 and had secured on the average 60.57 percent marks and almost 88.41 % 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 candidates had practiced before in the classrooms and these mere recall (knowledge level) questions for them. The section-wise performance of candidates is as given in table 2 and indicated in Fig 1.

Table 2: Accumulative performance.

Section	Performance Index	%
A	0.62	61.77
B	0.78	78.17
C	0.66	66.43
D	0.68	67.53
O/A	0.70	69.90

Fig. 1 Accumulative performance in all sections.

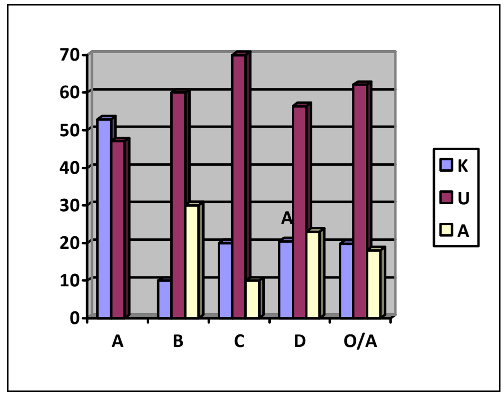


In certain questions where understanding of concepts or their application was required for answering, the candidates faced some difficulty in comprehending the requirements completely, especially in case of open ended questions contained in sections "B and C". In addition, the inappropriate composition and construction of questions including use of ambiguous terms caused hindrance in clarity for understanding the requirements of questions fully by some candidates 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 1-6), followed by "Section C (SRQs from chapters 7-11)", comparatively lower in case of "Section D" (ERQs) and the lowest in "Section A" (MCQs). The section-wise marks allocated to different question items according to their cognitive levels is given in table 3 and indicated as in Fig 2.

Table 3: Marks % - Cognitive Level

Section	Knowledge (K)	Understanding (U)	Application (A)
A	52.94	47.06	-
B	10	60	30
C	20	70	10
D	20.51	56.41	23.08
O/A	19.83	62.07	18.10

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:

<u>Question Paper</u>

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 used lacked needed clarity to correctly communicate the scope and requirements of the questions, needed to guide the students for answering them.

ii) Inability of paper setter to construct numerical questions where candidates could 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. The numerical questions, part question (iv) in "Section B", part question (vi) in "Section C" and questions 4c, 5c and 6c in "Section D" were taken with exactly the same wordings and requirements and hence were answered almost by all the candidates, through their previous knowledge and experience, who attempted them and attained good marks.

iii) Inability of paper setter to construct challenging MCQs "Section A". The candidates could easily pick up the correct answer without much difficulty as the answers were very obvious, due to poor distracters and attained good marks in this section. For example in part questions 1) to 7), 10) & 11), 14), 15) and 17) 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. Part question 9) did not include the 'pressure' which was the correct option and hence was incorrectly constructed.

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 examination 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 yes, no, explanation with formula, definition, correct calculation, correct proof, name of four applications 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 candidates 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 negates 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.

<u>Recommendations</u>

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 uniform assessment standard. In the present situation, in the absence of a reliable examination system, progress shown by the marks and grades attained by the students remains questionable.

ix) There should be no choice of questions (seven out of ten) be given in sections B & C, as the short response questions like MCQs in section A are given to ensure coverage of syllabi by all students. The presence of such concessions promotes the trend for selective study, thus encouraging the students to leave certain portions of syllabi without losing the opportunity to get maximum marks. Internationally such concessions are not given at their stage of education.

x) 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.

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

xii) Efforts of FBISE towards establishment and strengthening of question bank, prepared by the professionals besides continuous additions into it may help reduce issues of composition and construct of quality question papers.

PART III: QUESTION SPECIFIC COMMENTS

SECTION - A

Most of the candidates handled "Section A" very well in terms of attainment of good marks, although their overall performance in this section is the lowest when compared with other sections. Generally around fifty percent questions in this section required mere recall (knowledge level) of facts, terms, equations and definitions and remaining fifty percent were of understanding level. The part questions 8, 13 and 14 were not well answered due to multiple reasons and the prominent among them is the lack of preparation of the candidates of chapters on Angular Motion and Optics. Out of the remaining part questions candidates performed better in knowledge level MCQs while they faced some difficulties in answering part questions which required understanding of concepts for answering. Question Number One, an exclusive question in this section consisting of 17 compulsory Multiple Choice Questions "(MCQs)" as part or sub-questions. This question was attempted by all 19559 examinees and their overall achievement in this section is summarized in Table 4 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	6.57	22.97	38.07	19.84	12.55	9.59 (56.44)

Mean marks obtained in this section are 9.59 with an overall achievement index of 61.77 percent which is the lowest among all sections and around 16.40 percent lower than the best achievement index percentage in "Section B". The overall achievement of 61.77 percent has been highly spatial. About 29.54 percent of examinees are positioned in the two lowest quintiles of marks, about 38.07 percent in median quintile and around 12.55 percent of examinees could achieve more than eighty percent marks in this section.

Decomposition analysis of part questions revealed that nine questions asked were of mere "Knowledge Level", in which students had to recall stated facts, equations and units from the contents of the prescribed book. Those students who were good in memorization or recalling of facts performed relatively better. Since all questions were compulsory, without negative marking for incorrect answers, so everyone attempted all part questions and their reflected performance is higher than their actual one. Question and response analysis of this section is summarized in Table 5 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 $_{(0.23)}$	FI	PD	SD
1	61.66	18.87	8.33	11.14	K	0.60	0.62	C	--
2	37.62	51.35	6.30	4.73	K	0.35	0.51	C,D	A
3	8.38	30.59	5.45	55.57	U	0.56	0.56	A,C	B
4	13.90	61.54	12.71	11.84	K	0.63	0.62	--	--
5	7.85	9.58	14.35	67.32	K	0.60	0.67	A,B	--
6	9.89	17.56	57.11	15.45	U	0.69	0.57	A	--
7	20.22	50.43	12.91	16.44	U	0.67	0.50	--	A
8	23.95	34.34	27.19	14.52	K	0.57	0.34	--	A,C
9	11.76	65.47	1.52	21.25	U (IC)	0.58	0.65	C	D
10	28.94	5.13	61.81	4.12	U	0.50	0.62	B,D	A
11	19.16	57.62	13.06	10.16	K	0.59	0.58	--	A
12	5.06	19.68	59.28	15.99	U	0.35	0.59	B	A
13	12.38	19.75	28.27	39.5	U	0.58	0.40	--	B,C
14	32.05	39.78	10.45	17.72	K	0.52	0.40	--	A,D
15	25.54	6.29	64.58	3.58	K	0.62	0.65	B,D	A
16	14.76	73.16	7.69	4.38	K	0.63	0.73	C	--
17	74.15	8.58	14.00	3.27	U	0.59	0.74	B,D	--

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

Facility Index (FI): Generally it ranged between 50 and 75 percent in all part questions except for part Questions (8, 13 & 14) taken from chapters on Angular Motion and Optics where it is between 30 and 40 percent. The lower facility index reflects that these chapters were not properly prepared by the candidates. The overall performance of the candidates in MCQs appears to be dependent on two factors; the first one is the cognitive level of the part questions, which is lower in case of understanding level as compared to knowledge level and the second one is the quality of distracters, the performance is lower where distracters are stronger and higher where the answers are obvious or distracters are weaker.

Discrimination Index (DI):

In order to correlate the performance of the candidates in a part question with their overall score (combined 17 part 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 6157 (31.64 %) , overall FI (86.94) and 29.54 percent of the candidates are in the 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, fif**teen** items are found very good test items for having values equal or more than 0.4 and **two** items are reasonably good with DI value ranged from 0.30 to 0.39, (Ebel and Frisbie, 1986). Almost all seventeen 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, 35.29 percent of MCQs were found having only one effective distracter whereas, 17.65 percent MCQs were having two strong distracters, which is quite positive. Due to combined effect of around fifty percent MCQs of understanding level and presence of at least one stronger distracter in each MCQ, the overall performance of the candidates is the lowest in this section.

SECTION – B (Chapters 1 to 6)

Question number two was the single question in this section consisting of ten "Short Response Questions (SRQs)" as sub-questions, taken from chapters 1 to 6, and students were required to answer any seven out of them. Most of the candidates selected other questions in preference to application level sub-questions, (iv), (v), (vi) and (x), besides sub-question (ix) of knowledge level. It appears that they were less confident in answering application level questions and sub-question (ix) of knowledge level attempted by the least percentage (35 %) of the candidates due to lack of preparation of Chapter on Angular Motion for the examination. The facility index (FI) of question 2 is 0.87 and its discrimination index (DI) is 0.68. The overall performance of the candidates in this section was the best when compared with other sections who on the average secured 14.82 (70.57 %) marks and 22.83 % out of them secured 100 % marks.

Overall achievement of examinees in this section is summarized in Table 6 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	9.43	5.74	20.47	13.25	51.10	14.82 (70.57)

Decomposition analysis of sub-questions revealed that 60 percent questions in this section were of understanding level and 40 percent of Application Level (sub-questions iv, v, vi and x). 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 in Table 7 below:

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

Sub-question	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Attempted (Students %)	95	85	95	65	60	55	75	80	35	55
Cognitive Level (CL)	U	U	U	A	A	A	U	U	K	A

Question 2

i): Show that the expression $V_f = V_i - at$ is dimensionally correct, where V_i is the velocity at t = 0 and V_f is the velocity at time t.

Question asked required the candidates to find the dimensions of terms both on the LHS and RHS of the equation correctly especially that of "at" to show that it is the same as that of velocity. They were required to equate the equation as per dimensions to prove that terms on the LHS=RHS.

Question asked was of understanding level requiring the candidates to express the terms in the equations of motion in the form of dimensions. Almost 95 percent candidates attempted this question. However, about 5 percent of them faced some difficulty in finding the dimensions of the term "at" correctly and some of them were confused in equating the equation according to the dimensions.

ii): Give the drawbacks to use period of pendulum as a time standard.

This part question required from the candidates to give the equation for time period of a simple pendulum and to argue that since the length of pendulum changes with temperature and the value of "g" also changes with altitude so it cannot be used as time standard.

Question asked was of understanding level requiring the candidates to explain that the time period of a simple pendulum varies as its length changes with temperature and value of "g" with altitude. Almost 85 percent candidates attempted this question and successfully gave equation for time period of simple pendulum. However, about 30-40 percent of them faced some difficulty in correctly giving the reasons for change in time period.

iii) If one of the rectangular components of vector is not zero. Can its magnitude be zero? Explain briefly.

Question asked required the candidates to recall equations of rectangular components and to draw a diagram for explaining addition of rectangular components to give a resultant vector. They were asked to explain that these rectangular components vary independently and have no effect on each other and they were also required to explain that the magnitude of a vector can be zero only if both the components are equal to zero separately.

Question asked was of **knowledge-cum-understanding level** and almost 95 percent of the candidates attempted this question. They could easily recall the equations and also drew the diagram correctly. However, around 25 percent of them faced some difficulty and vaguely explained the reasons for the magnitude of the resultant vector not being zero if any component out of them is not zero.

iv) Define unit vector and find the unit vector in the direction of vector $\vec{A} = 4i + 3j$

The question asked required the candidates to give the definition of a unit vector stating that the magnitude of the vector should be one unit only and it can have any direction. The candidates were also required to derive the equation for the unit vector in terms of its rectangular components in the direction of the given vector, expressed in terms of its rectangular components as $\hat{A} = \frac{\vec{A}}{|\vec{A}|} = \frac{4i+3j}{|\vec{A}|}$

Question asked was of **knowledge-cum-application level** which was attempted by around 65 percent of the candidates, almost all of them recalled correctly the definition of a unit vector (knowledge level). However, they faced some difficulties in finding the unit vector in the direction of the given vector (application level), in which only around 30 percent of them could successfully give the answer completely whereas answers of around 15 percent were ambiguous, partial or irrelevant. Out of the 65 percent candidates who attempted this question only around 20 percent of them could attain maximum marks.

v) Can the velocity of an object reverse the direction when acceleration is constant? If so give an example.

This question required from the candidates to explain with the help of Newton's Second Law that acceleration produced in a body is always proportional and is in the direction of the net *force acting on it. They were asked to explain that when a constant force (constant acceleration) acts on a moving body against its initial velocity then first it slows down and after momentarily coming to rest restarts moving in the reverse direction increasing its velocity with the same acceleration. They were expected to explain with an example similar to that of a body thrown upwards against the force of gravity (-g constant acceleration), which gradually slows it down and on reaching to its maximum height it stops momentarily and then it restarts moving in the downward direction increasing its velocity with the same acceleration 'g'. They were also expected to emphasize that throughout in the motion of the body both magnitude and direction of the acceleration remains constant.*

Question asked was of **understanding-cum-application level** aimed to test the ability of the candidates to explain that the direction of acceleration of a body is in the direction of net force and is not connected in any way to its initial velocity. Almost 60 percent of the candidates attempted this question and explained it well, except for around 10 percent who were clueless. Around 30 percent of the candidates secured maximum marks in this part question.

vi) Find the angle of projection of projectile for which its maximum height and horizontal range are equal.

The question asked required from the candidates to give the equations of a projectile for its range and maximum height reached during its flight when projected with an initial velocity V_i *at angle* θ *with the horizontal direction. They were expected to equate the two equations to calculate* $\tan\theta = 4$ *and from this equation the angle of projection* $\theta = \tan^{-1} 4 = 76^{o}$.

Question asked was of **application level** aimed to test the ability of the candidates to equate the two equations for maximum height and range of a projectile, which is projected at an angle θ with an initial velocity V_i and to calculate the angle when maximum height and range are equal. This part question was attempted by almost 55 percent of the candidates, out of which around 20 percent calculated up to $\tan\theta = 4$ and only 10 percent were able to calculate the angle $\theta = \tan^{-1} 4 = 76^{o}$, the angle of projection.

vii) An object has 1J of P.E. what does it mean ?

This question expected from the candidates to define and explain Potential Energy of a body at a certain position. They were further expected to explain the process of conversion of potential energy through work done into any other form of energy as the body moves from one state to another at a lower potential energy. They were asked to explain that if a body has 1J of Potential Energy then it is capable of applying a force on another body and displacing it from one position to another such that the work done (scalar product of force in Newton and the displacement in meters) is equal to 1J. In this process the body loses IJ of *energy by moving from its present position to a lower position and the same energy of 1J is transferred to the body being displaced.*

Question asked was of **knowledge-cum-understanding level** aimed to test ability of the candidates to i) recall or define the concept of potential energy; ii) explain ability of a body to do work in order to transfer its potential energy into other forms or to the other bodies; and, iii) explain meaning of IJ potential energy. This question was attempted by almost 75 percent of the candidates. Out of them around 60 percent defined and explained the concept of potential energy correctly. However, out of them around 20 percent could explain the conversion of potential energy through work done into other forms of energy and only 15 percent could explain the meaning 1J of Potential energy. Besides, the construction of question was also ambiguous and confusing, not giving the direction and guidance in answering to meet the requirements fully.

viii) A girl drops a cup from a certain height, which breaks. What energy changes are involved?

This question required from the candidates to give the relation for potential energy possessed by the cup when it was at a certain height and were needed to explain that this potential energy is converted gradually into kinetic energy of the cup as it loses height and finally it is entirely in the form of kinetic energy when it hits the ground. They were expected to explain that when cup hits the ground its kinetic energy is converted into different forms, like heat, sound and kinetic energy possessed by the broken parts etc, however, total energy remains constant and equal to initial potential energy of the cup.

Question asked had three parts; the first one was of **knowledge level** in which candidates were to recall that a body possesses potential energy when it is at a certain height, the second one was of **understanding level** that potential energy of a body is converted into equivalent kinetic energy as it loses height and the third one was of again of understanding level that energy can be converted into other forms but it remains conserved. This was another well choice question attempted by over 80 percent of the candidates. Amongst them, over 75 percent successfully met the first two requirements. However, they faced some difficulty and around 40 percent candidates were successful in showing that total energy remains conserved and can change from one form to another. Almost all candidates secured good marks in this question.

ix) What is meant by angular momentum ? Show that L_0 = mvr

This question asked required from the candidates to define angular momentum and recall relationship of angular momentum in terms of moment arm and linear momentum in the vector form and were also expected to show that magnitude of angular momentum of a particle having mass m moving with a velocity v in a circle of radius r around an axis of *rotation passing through origin of the circle and perpendicular to the plane of moment arm and velocity of the particle is,* $L_0 = mvr$.

Question asked was of **knowledge level** requiring the candidates to recall the definition of angular momentum and its relationship as cross product of moment arm and the linear momentum of the body. Further, they were required to reproduce the relationship for the magnitude of angular momentum in terms of mass of the body, its velocity and the moment arm as given in the book. This was the lowest choice question attempted by about 35 percent of the candidates. Amongst them, around 60 percent of them were able to correctly meet the requirements of the question and could secure maximum marks. The lower percentage of candidates attempting this question reflects that the majority of them had not fully prepared the chapter on circular motion for examination.

x) A person is standing near a fast moving train. Is there any danger that he will fall towards it ?

This question required from the candidates to recall Bernoulli's Equation and apply it to an air column moving with the velocity of the train on a horizontal track assuming that no change in the density of air occurs. They were expected to argue that moving air column is having lower pressure as compared to the stationary air where the person is standing and hence he will fall towards the train as the pressure is comparatively lower in that direction.

Question asked is of **application level** aimed to test ability of students to recall the Bernoulli's Equation and understand that moving fluid (air) has comparatively lower pressure as compared to that of stationary one and apply it to the situation given in the question. Since the question was taken from those questions which are given at the end of the chapter so it was mere recall for those who had already done it in the classroom. Despite this, this question was attempted by around 55 percent of the candidates out of whom only one fourth could answer satisfactorily to secure maximum marks.

SECTION – C (Chapters 7 to 11)

Question number three was the single question in this section consisting of again 10 "Short Response Questions (SRQs)" as sub-questions, taken from chapters 7 to 11, and the candidates were required to answer any 7 out of them. The sub-questions, (v), (vi), (vii) and (x) were attempted by comparatively lesser number of candidates perhaps, either the other questions were easier and they were more confident of scoring better marks or had carried out selective preparation and had partially prepared chapters related to Optics and Thermodynamics for the examination. Since all questions including numerical problem given as part question (vi) were taken from the book without even changing their wordings so the candidates who had spent more time in preparation for the examination secured better marks.

However, the performance of the candidates in this section was better when compared with "Section A" but lower than that of "Sections B&D". The facility index (FI) of question 3 is 0.80 and its discrimination index (DI) is 0.61. The overall performance of the candidates in this section is fairly good who on the average secured 12.21 (58.17 %) marks and 11.71 % out of them secured 100 % marks. Overall achievement of examinees in this section is summarized in Table 8 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	15.47	10.51	28.53	17.42	28.08	12.21 (58.17)

Decomposition analysis of sub-questions revealed that 70 percent questions in this section were of understanding level, 20 percent of Knowledge level (sub-questions i and ix) and 10 percent of application level (sub-question vi). Those candidates who were good in conceptual understanding of the subject performed relatively better. Since candidates were required to choose any seven sub-questions out of ten so there was a general trend to select the questions requiring lower cognitive demands besides avoiding questions from chapters on Optics and Thermodynamics. Question and response analysis of this section is summarized in Table 9 below:

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

Sub-question	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Attempted (Students %)	85	95	80	90	75	55	70	50	45	55
Cognitive Level (CL)	U	K	U	K	U	A	U	U	U	U

Question 3

i): Does the acceleration of simple harmonic oscillator remain constant during the motion? Is the acceleration ever zero? Explain briefly.

This question asked required from the candidates to state that for a simple harmonic oscillator the magnitude of acceleration is always directly proportional to the displacement and is opposite in direction. Candidates were required to explain that displacement varies from its extreme position $+x_0$ *through mean position '0' to the opposite extreme position* $-x_0$ *and then back to '0' and to the maximum* $+x_0$ *again in a cycle of vibration. The candidates were required to argue that the acceleration is zero twice in a cycle when it is at the mean position where its displacement is zero.*

Question asked had two parts; the first one was of **knowledge level** requiring candidates to recall the conditions for a simple harmonic oscillator which almost 85 percent answered correctly, the second one was of **understanding level** which required to explain that acceleration is dependent upon the displacement and is zero where displacement is zero was answered by around 50 percent of the candidates satisfactorily. However, about 15 percent of them faced some difficulty in explaining and appeared to be confused as their explanations were irrelevant. Around 20 percent candidates answered this question correctly and secured maximum marks.

ii): Define resonance and name any two phenomena in which resonance is involved.

This question required the candidates to state that the conditions for resonance to occur in an oscillator are that when the frequency of external periodic force applied to an oscillator is comparable with the natural frequency of the oscillator then the amplitude of the oscillator increases, called resonance, and its amplitude is the maximum when the two are exactly the same. They were expected to name two examples from everyday life where resonance occurs and needed to explain that how the essential conditions are met in these examples.

Question asked consisted of two parts; one was of **knowledge level** which required the candidates to recall the conditions for resonance to occur when an external periodic force is applied to an oscillator, which was answered correctly by almost 95 percent of the candidates, and the second one was of **understanding level** requiring the candidates to give examples from everyday life in which resonance occurs and were also required to explain that how the conditions are met. However, the second part was answered vaguely by most of the candidates except for 15 percent who answered reasonably well.

iii) Why does sound travel faster in warm air than in cold air?

This question asked the candidates to give the equation for velocity of sound with Laplace correction. They were required to state that the velocity of sound is inversely proportional to square root of density of air through which it travels. Candidates were expected to argue that as the density of air decreases with increase in temperature so the velocity of sound increases with increase in temperature. Therefore, velocity of sound will be higher in the warm air.

Question asked consisted of two parts the first one was of **knowledge level** requiring the candidates to recall equation for the velocity of sound with Laplace correction which was answered by almost all 80 percent of the candidates correctly who attempted this part question and the second one was of **understanding level** in which they were required to explain the dependence of velocity of sound on the density of air, which reduces with the increase in temperature. They were expected to argue that the velocity of sound increases in warm air due to lowering of its density. Around 35 percent of the candidates directly gave the correct answer without giving the reasons. However 10 percent of them could meet all the requirements of the question and secured maximum marks.

iv) Define terms crest, trough and node.

This question expected from the candidates to give the graphical representation of longitudinal or transverse waves. They were asked to define the crest, as the maximum upward displacement of particles of the medium in a surface wave during a cycle from their mean position in case of transverse waves, whereas, in case of longitudinal waves the compression of particles is the maximum at the crest.
Candidates were asked to define trough as, the maximum displacement of particles of the medium in the opposite direction to that of crest or at the lowest point in a surface wave from their mean position in a cycle in case of transverse waves, and there is maximum rarefaction in case of longitudinal waves.
They were required to define the node as the point where amplitude of wave remains zero or particles stay at their mean position. For longitudinal waves there is no compression or rarefaction. In case of both transverse and longitudinal waves, the particles of the medium are not displaced from their mean position at any particular time.
Question asked was of **knowledge level** in which candidates were required to recall three definitions; the first one of crest, second one was of trough and the third one that of a node. Almost all the 90 percent candidates who attempted this question gave correctly the definitions of crest and trough except for around 45 percent who faced some difficulty in recalling the definition of node correctly. Generally the candidates performed extremely well in this part question.

v) Define coherent sources. Under what conditions two sources of light behave as coherent sources?

This question required from the candidates to define coherent sources as those which have the same frequency and are in phase to each other. The candidates were asked to explain that the emission of light is a random or spontaneous process so independent separate sources cannot be phase coherent even if they are having same frequency. The candidates are expected to argue that the sources of light having one origin only will be phase coherent as these are always in phase to each other.

Question asked consisted of two parts; the first one was of **knowledge level** in which candidates were required to define coherent sources and the second one was of **understanding level** aimed to test the ability of the candidates to explain that how the conditions for coherence of two sources are met, when the light is emitted through a process which is random or spontaneous. Almost 75 percent of the candidates attempted this question and around 50 percent faced difficulty in correctly stating the coherent sources while in the second part of question majority of them gave the procedure of producing coherent sources rather than focusing on arguing about meeting the conditions. However, around 15 percent of them correctly answered the question and secured maximum marks.

vi) In a double slit experiment, the second order maximum occurs at $\theta = 0.025^0$. The wavelength is 650 nm. Find the slit separation.

This question required from the candidates to give the equation for the constructive interference, d Sin θ = m λ. The candidates were expected to substitute the given data after *converting it into SI system of units and to calculate the separation of slits as d = 29.78 mm.*

This question consisted of two parts; the first one was of **knowledge level** which required from the candidates to give the equation of constructive interference and the second one was of **application level** requiring from them to first convert the data into SI units before substituting in the equation and were also expected to express the calculated value into more understandable unit i.e. millimeter in this case. Almost 55 percent of the candidates attempted this question and majority of them answered the first part correctly while in the second part, around 10 percent out of them either converted the value of wavelength incorrectly into SI units or substituted the values as given in the question.

vii) What do you understand by linear magnification and angular magnification? Write the equations as well.

This question required from the candidates to give definition of Linear Magnification as the ratio between image length and the object length as measured in the planes perpendicular to the optical axis. They were also required to define the Angular Magnification as the ratio between angles subtended by the image of the object as seen through the optical device to that of the object at unaided eye. They were expected to explain both linear and angular magnifications with help of diagrams. They were asked to give the relationships of Linear Magnification $m = II' / OO'$ *and Relationship for Angular Magnification* $M = \beta/\alpha$

Question asked was of **knowledge-cum-understanding level** in which the candidates were required to recall (knowledge level) the definitions of both linear and angular magnifications besides writing their equations. They were required to explain (understanding level), expectedly with diagrams, both linear and angular magnifications. Over 70 percent of the candidates attempted this question and their answers for the first part (knowledge level) were generally correct, while in the second part (understanding level) around 10 percent of them were confused and gave irrelevant explanations of magnifications.

viii) How the light signal transmitted through the optic fibre?

In this question candidates were required to give the conditions for Total Internal Reflection and were asked to explain that the transmission of light signal through optic fibre is by continuous total internal reflections as it travels through the optic fibre from one place to another. Further, they were expected to state that during total internal reflections there is no signal loss. They were also expected to explain that critical angle depends upon frequency or wave length of the light signal to be transmitted which determines the materials to be used and construction of optic fibre.

Question asked had two parts; the first one was of **knowledge level** in which candidates were to recall that the light signal undergoes continuous total internal reflections as it travels through the optic fibre and the second one was of **understanding level** in which candidates were required to explain that how the conditions of total internal reflection of light signal are met when it moves through an optic fibre and the role of construction material and design of the optic fibre. This was not a well choice question and was attempted by around 50 percent of the candidates. Amongst them, more than half successfully answered the first part while the second part was answered correctly by one fourth of them and remaining were generally confused, ambiguous and irrelevant in answering the second part.

ix) Show that $C_p - C_v = R$

The candidates were required to give the mathematical expression for the First Law of Thermodynamics and also define the specific heats at constant pressure (C_p) and at constant volume (C_v). They were expected to prove by using the First Law of Thermodynamics that specific heat at constant pressure (C_p) is higher than the specific heat at constant volume (C_v) by R, molar gas constant i.e. $C_p - C_v = R$.

Question asked was of **understanding level** requiring the candidates to recall the definitions of specific heats at constant pressure and at constant volume and to use First law of thermodynamic to establish and prove the relationship as asked. This was one of the low choice questions attempted by around 45 percent of the candidates and majority of them answered it correctly and secured maximum marks.

x) Is it possible to convert internal energy into mechanical energy? Explain briefly with an example.

Question asked was of ***understanding level*** *in which candidates were required to use mathematical expression for the First Law of Thermodynamics in case of adiabatic expansion of an ideal gas. They were required to explain that when pressure is reduced its volume increases and temperature is lowered. They were asked to explain that work done by the expanding gas is at the expense of internal energy of the system (gas) which is a function of temperature only (lower is the temperature lower is the internal energy). Hence mechanical energy becomes available due to conversion of internal energy in the form of mechanical energy.*

Question asked was of **understanding level** which required the candidates to state that it is possible in an adiabatic process when a gas is allowed to expand against an external pressure. They were expected to explain that as a consequence of work done in expanding the gas its temperature decreases and the rate of reduction of temperature is directly proportional to the work done by it. They were expected to argue that since internal energy is a function of temperature alone so the internal energy can be converted into mechanical energy. This was not a very popular choice question of the candidates and around 55 percent of them attempted it and a majority out of them confused it with the cyclic process which takes place in Carnot Cycle and thus answered incorrectly. However, 15 percent of the candidates who attempted this question answered correctly and secured maximum 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 questions were of knowledge, 22 (56.41 %) marks questions were of understanding and 9 (23.08 %) marks questions were of application levels. The overall achievement of the candidates in this section has been lower when compared with sections "B&C", however, better than that of "Section A" and they on the average secured 15.14 (58.24 %) 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 candidates varied from question to question according to their cognitive levels. Approximately, a total of 81.78 percent out of 97.83 percent candidates who attempted this question, succeeded in attempting two required questions from this section. Out of them around 49.33 percent attempted questions 4&5, 28.44 percent attempted questions 4&6 and only around 4 percent attempted questions 5&6. Approximately around 8 percent candidates secured 100 percent marks in this section. Overall achievement of candidates in this section is summarized in Table 10 below:

Table 10 : Distribution of candidates against different level of achievement

Marks	1 – 5	6 – 10	11 - 16	17 – 21	22 – 26	Mean (Percentage)
Percentage	15.85	13.93	22.67	11.85	35.70	15.14 (58.24)

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 candidaes 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. Further, the least choice question in this section was Q6, taken from chapter on Optics, was attempted by only 33.33 percent of the candidates, reflecting their lack of preparation. Question and response analysis of this section is summarized in the table 11 below:

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

Question	Q.4	Q.5	Q.6	Section D
Cognition Level	K = 23.08 % U = 46.15 %	K = 23.08 % U = 38.46.15 %	K = 15.38 % U = 84.62 %	K = 20.51 % U = 56.41 %

	A = 30.77 %	A = 38.46 %	A = - %	A = 23.08 %
Average Marks (Percentage)	8.91 (68.55 %)	8.34 (64.17 %)	6.75 (51.91 %)	15.14 (58.24 %)
Facility Index (FI)	0.78	0.71	0.69	0.75
Discrimination Index (DI)	0.52	0.48	0.44	0.94

Facility Index (FI): It ranged from 0.69 to 0.78 in all questions. Facility index of question number 6, involving optical instruments (compound microscope, its working and magnification power), types of optic fibre and a numerical problem regarding angular magnification of a telescope was the lowest 0.69. 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 0.44. The DI value of combined "Section D" is 0.94, 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 (0.87 & 0.80) and their discrimination indices (0.68 & 0.61) 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

Q4.

a. Define scalar product. Write down two examples and four characteristics of each.
b. Discuss conditions of equilibrium.
c. Find the angle between two vectors $\vec{A}$ =5i – j and $\vec{B}$ =2i – 4j

This question comprised of three parts;

In part a. candidates were required to define Scalar and Vector products of two vectors with diagrams and were asked to give two examples of each when two vector quantities are multiplied resulting in a scalar quantity in the first case and a vector quantity having direction orthogonal to both the multiplying vectors in the second case. They were also required to give four characteristics of the scalar product of two vector quantities, which include i) commutative, ii) when these are parallel/anti-parallel , iii) when these are orthogonal to each other, iv) with self vectors (two equal vectors) and v) by rectangular *components. They were also required to give four characteristics of the vector product of two vector quantities which include i) order dependence of multiplication, ii) Null vector when these are parallel/anti-parallel vectors, iii) have maximum magnitude when vectors are orthogonal to each other and iv) each resultant rectangular component is orthogonal to the multiplying rectangular components.*

In part b, the candidates were required to discuss that a body can be in a state of equilibrium when both the linear and angular accelerations are zero. They were also required to discuss that for a translational equilibrium, all the rectangular components of the resultant force acting on the body must be zero individually and for rotational equilibrium sum of all torques acting on the body must be zero,

In part c, the candidates were expected to represent both the given vectors graphically. They were required to find magnitudes of the given vectors and the value of scalar product from the rectangular components of the vectors. By using equation for the scalar product in terms of magnitudes of the two vectors were required to calculate value of cos θ and hence the value of θ, the angle between the given vectors.

Question asked was of **knowledge, understanding and application levels** and was attempted by around 89.42 percent of the candidates. It consisted of three parts: the first part was of **knowledge level** which required mere recalling of definitions of scalar and vector products along with the four characteristics of each. Almost 70 percent of the candidates answered it correctly except for around 20 percent who faced some difficulty or were confused in recalling the characteristics; the second part was of **understanding level** and was not consistent with the first part, contrary to general practice. Almost 85 percent of candidates answered it correctly except for around 10 percent of them who either mixed up the two conditions of equilibrium or gave incomplete answers. The part c of the question was consistent with the first part and was of **application level,** requiring the candidates to use equations for the scalar product both in terms magnitudes of individual vectors involved and in terms of their rectangular components. Since the numerical problem was taken verbatim from the book so majority of the candidates around 75 percent out of those who attempted the question answered it correctly. Overall achievement of examinees in this question is summarized in Table 12 below:

Table 12 : Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 – 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	11.99	15.07	5.67	13.78	53.48	8.91 (68.55)

Q5.

a. What are stationary waves? How are stationary waves generated? Discuss stationary waves in a stretched string.
b. What are applications of Doppler's Effect? Discuss briefly.
c. An organ pipe has a length of 50 cm. Find the frequency of fundamental note when it is open at both ends (Speed of sound = 350 ms^{-1})

This question comprised of three parts;

In part a, candidates were required to define stationary waves as standing waves in which positions of nodes and antinodes remain fixed and the particles of the medium at the nodes remain stationary while those at the antinodes undergo maximum displacement from their *mean positions. The candidates were expected to explain that the energy of the particles keeps changing its form from wholly potential energy when all particles are at their maximum amplitudes to wholly kinetic energy when all of them pass through their mean positions at a time during their periodic motion; however, no transfer of energy takes place across the nodes. Candidates were also expected to explain that the stationary waves are generated as a result of two waves which are simultaneously travelling in the opposite directions in a medium and are having the same frequency and amplitude. Candidate were required to draw the diagram showing a stretched string fixed at two ends and were also required to explain that when string is plucked from the centre, the two waves are generated as it is let free to vibrate. They were expected to discuss that these two waves, travelling in opposite direction having same frequency and amplitude, generate the standing waves in the string and both of these waves keep moving on the string in the opposite directions due to continuous reflections from the opposite fixed ends. They were required to state that the minimum frequency of the stationary waves which can be generated on a string is called fundamental frequency and their higher frequencies, which are integral multiples of the fundamental frequency, are called overtones. They were needed to state that the shape of the stationary waves produced on a string resembles with that of a sine wave curve. Further, they were required to give the equation for the velocity of stationary waves on a stretched string as* $V = \sqrt{\frac{F}{m}}$ *and their wave lengths as λ/2, λ, 3λ/2, 2λ, 5 λ/2, 3λ, and so on. They were also expected to write the equations for the fundamental frequency as* $f_1 = \frac{\sqrt{F/m}}{2l}$ *and for the overtone as* $f_n = n\frac{\sqrt{F/m}}{2l}$.

In part b, candidates were asked to give applications of the Doppler Effect, stated as the change in the apparent frequency of waves when there is a relative motion between source and the listener, and were also required to discuss the applications briefly, like;

i) Radar which transmits short bursts of electromagnetic waves which when reflected from an aero plane are received by the Radar as an echo and through comparison of frequencies of transmitted and reflected waves, the frequency shift is noted which is used to find the speed and direction of motion of an aero plane.

ii) Sound Navigation and Ranging (Sonar) uses the frequency shift of sound waves when there is a relative motion between source and the target. This is used for detecting under water movement of submarines etc.

iii) Astronomer use frequency shift in the emitted spectra, to calculate the speeds of distant stars and galaxies, through comparison with the laboratory source.

iv) On the highways frequency shift is used to measure speed of the vehicles.

In part c, candidates were required to graphically represent the sound waves generated by an open ended organ pipe in which antinodes are on the both open ends of the organ pipe while each node is half way between the two antinodes. They were required to state that the distance between the two endpoint antinodes is half of the wavelength and is equal to the length of the pipe in case of the fundamental frequency. Candidates were expected to calculate the fundamental frequency by using the given speed of sound and the length of the pipe.

Question asked was of **knowledge, understanding and application levels** and was attempted by around 55.07 percent of the candidates. In part a, over 80 percent of them gave the conditions for generating the stationary waves correctly and around 45 percent out of them explained the locations of nodes and anti-nodes in case of stretched string only. However, around 20 percent discussed creation of nodes and anti-nodes whereas less than 5 percent could explain the conversion of potential energy into kinetic energy of the particles of the medium during vibrations in stationary waves and less than one percent had the idea that energy does not flow across the nodes. In part b, over 80 percent out of those candidates who attempted this question recalled the applications of Doppler's Effect satisfactorily and only a few less than 5 percent faced some difficulty and gave confused answers. In part c, the candidates were asked to solve a numerical problem taken verbatim from the book, which demanded conversion of units of wavelength into SI system of units and recalling of relationship between speed of sound with its frequency and wavelength. This was attempted correctly by almost all candidates who answered this part. Overall achievement of examinees in this question is summarized in Table 13 below:

Table 13 : Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 – 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	53.62	9.13	2.75	11.16	23.33	8.34 (64.17)

Q6.

a. What is compound microscope? Discuss its working and find out its magnifying power.
b. Discuss different types of optic fibre.
c. A telescope is made of an objective of focal length 20 cm and an eye piece of focal length 5 cm. Find the angular magnification.

This question comprised of three parts;
In part a, candidates were required to define that the compound microscope is an optical instrument for forming magnified images of small objects and which consists of an objective lens of small focal length and an eyepiece of large focal length mounted in the same tube. They were expected to draw a ray diagram showing that an inverted and magnified image is formed by the objective lens of the object which is formed between f and 2f and its image is formed beyond 2f of the objective lens but inside the focal length of the eyepiece which magnifies it further by forming a virtual and erect image on the same side. The candidates were expected to give the formula for the magnification by the objective lens as $M_1 = \frac{q}{p}$ *and the formula for the magnification due to eyepiece as* $M_2 = 1 + \frac{d}{f_e}$ *and hence the total magnification* $M = M_1 M_2 = \frac{q}{p}\left(1 + \frac{d}{f_e}\right)$.
In part b, the candidates were required to state that transmission of light signal through optic fibre is by continuous total internal reflections, which take place as the light signal travels through it. The candidates were expected to explain that while designing and constructing the optic fibre the conditions for total internal reflection are kept in view which depend upon, the nature of materials used, design of core and surrounding layers and the wavelength of light signal used for transmission. They were required to discuss different types of optic fibre, their construction diagram and passage of light signal through them like; i) Single Mode Step Index fibre, ii) Multimode Step Index fibre and Multimode Graded Index fibre.

In part c, the candidates were asked to solve a numerical problem in which they were required to give the formula for angular magnification of telescope which is $M = \frac{f_o}{f_e}$. *They were expected to convert the data in SI units and to calculate magnification by substituting the given data. The angular magnification comes out as M= 4.*

Question asked was of **knowledge, understanding and application levels**. This was the least choice question of this section and was attempted by around 33.33 percent of the candidates with overall moderate achievement. In part a, almost 90 percent of the candidates who attempted this question gave correct definition and construction of the compound microscope and out of them around 45 percent only could explain the working properly. However, they faced difficulties in deriving the equation for the magnifying power of the microscope and only about 15 percent answered this part correctly to secure maximum marks. In part b, around 15 percent of the candidates who attempted this part could give satisfactory answers whereas majority of them around 60 percent were confused, irrelevant and ambiguous in answering besides about 15 percent out of them gave incomplete answers. In part c, the candidates were asked to solve a numerical problem taken verbatim from the book, which demanded of recalling the relationship for the angular magnification, and candidates were required to calculate angular magnification of a telescope by substituting values of focal lengths in the equation. Almost over 50 percent of the candidates who attempted this part answered it correctly. However, a sizable percentage almost 35 percent used the focal lengths in centimeters instead of meters required by SI system of units, which was to be preferably used. As conversion of units did not affect the result so candidates were given full credit, whether they converted or not converted the given data into SI system of units. Overall achievement of candidates in this question is summarized in Table 14 below:

Table 14: Distribution of candidates against different levels of achievement

Marks	1 – 3	4 – 5	6 – 8	9 – 10	11 – 13	**Mean (Percentage)**
Percentage	0.00	26.15	22.56	33.85	17.44	6.75 (51.91)

<u>Summary</u>

The higher facility and discrimination indices suggest that the paper was reasonably good and candidates performed extremely well in answering the questions. However, since all questions were given from the prescribed book so the candidates who had spent more time in preparation performed better in all the questions. The positive higher value of discrimination index reflects that those candidates 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 candidates had to mere recall them (knowledge level). The question-wise candidates 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

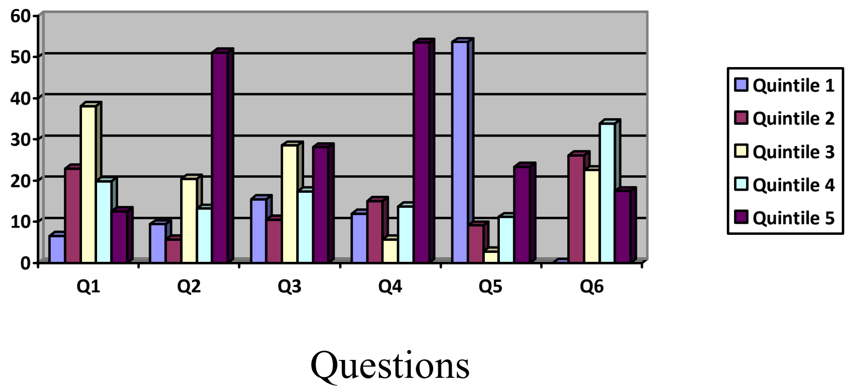


Figure 4 Question-wise percentage of candidates securing full (100%) marks.