G.C.E. (A.L.) Examination - 2016

Evaluation Report

01 - Physics

Research & Development Branch
National Evaluation & Testing Service
Department of Examinations

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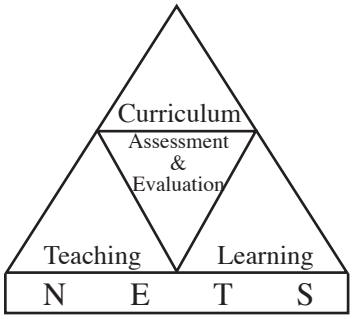

Research and Development Branch
National Evaluation and Testing Service

Physics

Evaluation Report - G.C.E.(A.L.) Examination - 2016

Financial Aid

Transforming the School Education System as the Foundation of a Knowledge Hub Project (TSEP-WB)

INTRODUCTION

The General Certificate of Education (Advanced Level) Examination is the final certification examination of the Senior Secondary Education in Sri Lanka. Though certification of the students' achievement level at the end of Senior Secondary Education is the major aim of this examination, it has a remarkable position as an achievement test as well as a selection test for candidates who are eligible for the admission of national universities and other higher education and vocational training institutes and National Colleges of Education. This has also been accepted as an examination that certifies entry qualifications for the tertiary level employments. 211865 school candidates under new syllabus and 46328 private candidates sat this examination in the year 2016.

Much efforts are being put forward by students to acquire a higher achievement level and teachers and parents to fulfil the expectations of the students in this examination. This evaluation report has been prepared by the Department of Examinations to assist the achievement of their goals. It is certain that the information provided by this evaluation report is equally important for candidates, teachers, principals, in-service advisers, subject directors, parents and researchers in education. Therefore it is important to direct this report for wider reference.

This evaluation report comprises of three parts. I, II and III.

Part I of this report consists of information related to aims and achievement of the subject Physics in G.C.E. (A.L) Examination. Under that the statistical information on subject achievement such as number of candidates sat for the subject, the way that they have obtained the grades, how the school candidates have obtained the grades in district wise and distribution of marks according to class intervals are included. A comprehensive analysis of the subject achievement that reveals how candidates have selected questions in Papers I and II in Physics and how they have scored marks for the questions and the sub parts of each question is also included. Part II of this report is included the questions in Paper I and Paper II of Physics in the G.C.E. (A.L) Examination 2016 and information about the candidates' responses. It includes expected answers for the questions of papers I and II, the scheme of marking, observations on answering, conclusions and constructive suggestions.

This evaluation report has been prepared by the Research and Development Branch of the Department of Examinations based on the information, observations, ideas and suggestions provided by chief examiners, additional chief examiners and assistant examiners who were involved in evaluating answer scripts and the information drawn through the analysis of candidates' responses using the Classical Test Theory and the Item Response Theory.

Part III of this report embodies the facts that should be taken into consideration by the candidates when answering each question and opinions and suggestions to improve learning teaching process. I think that this report is of immense value in organizing the learning teaching process to achieve respective competencies and competency levels.
You are kindly requested to direct your productive ideas and suggestions to us to improve the quality of our future evaluation reports.

I wish to extend my heartfelt gratitude to the chief examiners, additional chief examiners and assistant examiners who provided information to prepare this report, the Panel of Writers who fervently and actively contributed to the task, the officers and the staff of the Department of Examinations who engaged responsibly and the Project, Transforming the School Education System as the Foundation of a Knowledge Hub (TSEP-WB) that provided financial assistance for this.

B. Sanath Pujitha
Commissioner General of Examinations

01st of December 2017
Research & Development Branch
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Part I

1. Subject objectives and information on subject achievement

1.1 Subject objectives

At the end of completion of the course, the student

1. acquires sufficient understanding and knowledge to live as a confident citizen in the technological world.

2. recognizes the usefulness and boundaries of scientific method and appreciates its applicability in everyday life.

3. develops abilities and skills that are relevant to the studying and application of Physics in day-to-day life.

4. builds up attitudes relevant to Physics such as concern for accuracy and precision, objectivity, enquiry, initiativeness and creativity.

5. stimulates interest and care for the environment.

6. acquires manipulative, observational and experimental skills together with hands-on experience on the equipment used by physicists.

1.2 Statistical information on subject achievement

1.2.1 Number of candidates sat for the subject

Medium	School	Private	Total
Sinhala	51460	11969	63429
Tamil	8891	1626	10517
English	3105	625	3730
Total	**63456**	**14220**	**77676**

Table 1

1.2.2 Grades obtained by the candidates

Grade	School Candidates		Private Candidates		Total	Percentage
	Number	Percentage	Number	Percentage		
A	2060	3.25	432	3.04	2492	3.21
B	4488	7.07	1281	9.01	5769	7.43
C	12432	19.59	3209	22.57	15641	20.14
S	22857	36.02	5143	36.17	28000	36.05
F	21619	34.07	4155	29.22	25774	33.18
Total	**63456**	**100.00**	**14220**	**100.00**	**77676**	**100.00**

Table 2

1.2.3 Grades obtained by school candidates who sat the examination for the first time - District wise

District	No. Sat	Distinction (A)		Very Good Pass (B)		Credit Pass (C)		Ordinary pass (S)		Pass (A+B+C+S)		Weak Pass (F)	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
1. Colombo	6305	364	5.77	515	8.17	1339	21.24	2144	34.00	4,362	69.18	1943	30.82
2. Gampaha	3612	74	2.05	182	5.04	666	18.44	1305	36.13	2,227	61.66	1385	38.34
3. Kalutara	2164	31	1.43	86	3.97	336	15.53	856	39.56	1,309	60.49	855	39.51
4. Kandy	2831	102	3.60	153	5.40	511	18.05	1034	36.52	1,800	63.58	1031	36.42
5. Matale	625	12	1.92	22	3.52	80	12.80	240	38.40	354	56.64	271	43.36
6. Nuwara Eliya	868	6	0.69	37	4.26	106	12.21	279	32.14	428	49.31	440	50.69
7. Galle	2558	60	2.35	130	5.08	404	15.79	848	33.15	1,442	56.37	1116	43.63
8. Matara	1984	60	3.02	85	4.28	309	15.57	669	33.72	1,123	56.60	861	43.40
9. Hambantota	1327	20	1.51	48	3.62	180	13.56	461	34.74	709	53.43	618	46.57
10. Jaffna	1247	67	5.37	114	9.14	256	20.53	423	33.92	860	68.97	387	31.03
11. Kilinochchi	170	3	1.76	10	5.88	27	15.88	57	33.53	97	57.06	73	42.94
12. Mannar	163	1	0.61	4	2.45	23	14.11	59	36.20	87	53.37	76	46.63
13. Vavuniya	286	11	3.85	9	3.15	44	15.38	93	32.52	157	54.90	129	45.10
14. Mullativu	165	3	1.82	4	2.42	12	7.27	54	32.73	73	44.24	92	55.76
15. Batticaloa	706	26	3.68	51	7.22	153	21.67	253	35.84	483	68.41	223	31.59
16. Ampara	1151	21	1.82	52	4.52	197	17.12	421	36.58	691	60.03	460	39.97
17. Trincomalee	489	11	2.25	29	5.93	73	14.93	159	32.52	272	55.62	217	44.38
18. Kurunegala	2862	56	1.96	98	3.42	374	13.07	977	34.14	1,505	52.59	1357	47.41
19. Puttalam	1085	20	1.84	41	3.78	161	14.84	415	38.25	637	58.71	448	41.29
20. Anuradhapura	1347	16	1.19	49	3.64	154	11.43	401	29.77	620	46.03	727	53.97
21. Polonnaruwa	488	2	0.41	6	1.23	45	9.22	136	27.87	189	38.73	299	61.27
22. Badulla	1461	28	1.92	78	5.34	211	14.44	529	36.21	846	57.91	615	42.09
23. Monaragala	625	3	0.48	13	2.08	63	10.08	204	32.64	283	45.28	342	54.72
24. Ratnapura	1747	29	1.66	87	4.98	258	14.77	631	36.12	1,005	57.53	742	42.47
25. Kegalle	1562	20	1.28	53	3.39	219	14.02	609	38.99	901	57.68	661	42.32
All Island	**37,828**	**1,046**	**2.77**	**1,956**	**5.17**	**6,201**	**16.39**	**13,257**	**35.05**	**22,460**	**59.37**	**15,368**	**40.63**

Table 3

1.2.4 Distribution of final marks in class intervals

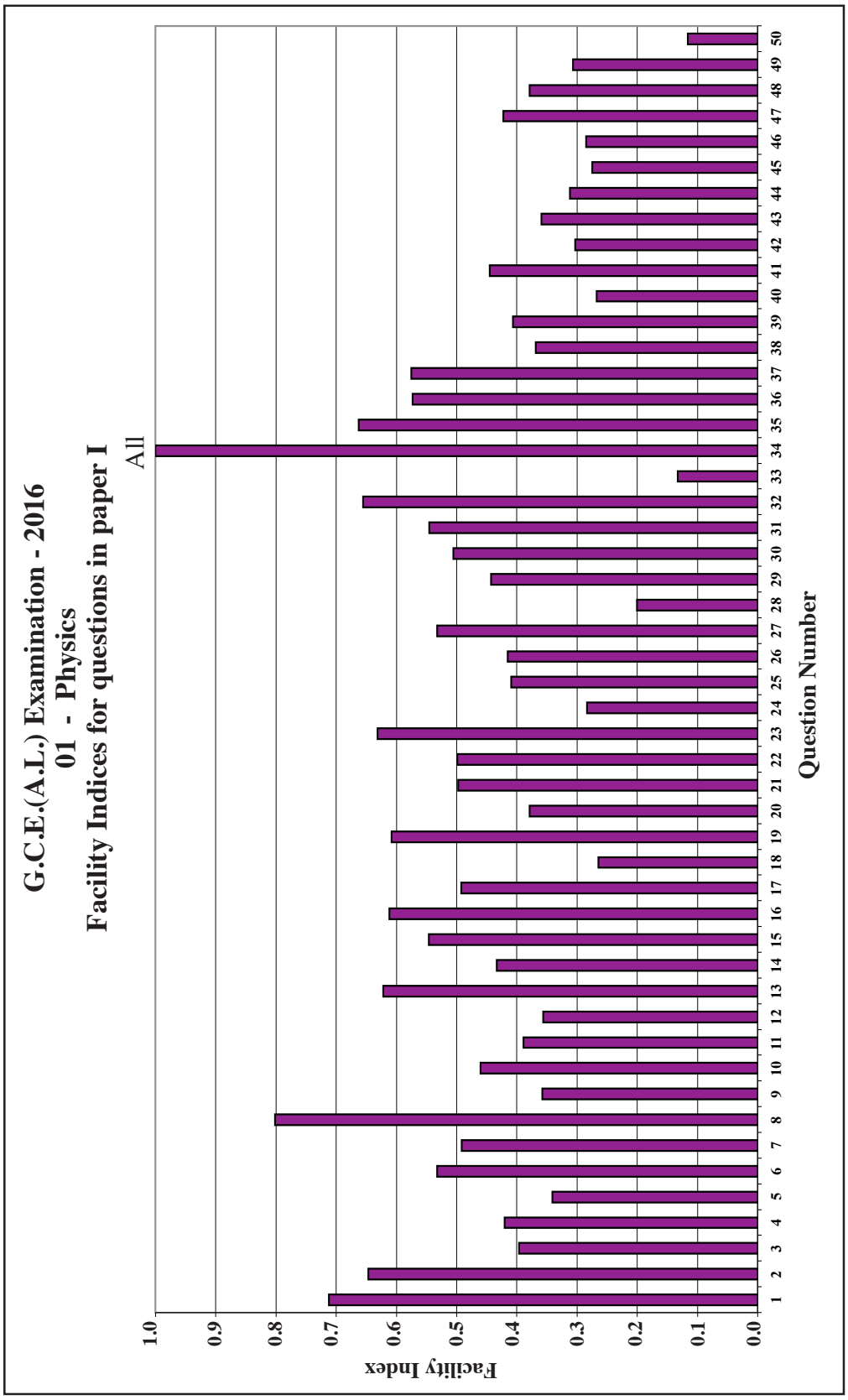
Class Interval	Frequency	Frequency as a Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91 - 100	24	0.03	77676	100.00
81 - 90	574	0.74	77652	99.97
71 - 80	3227	4.15	77078	99.23
61 - 70	6885	8.86	73851	95.08
51 - 60	10592	13.64	66966	86.21
41 - 50	14875	19.15	56374	72.58
31 - 40	17491	22.52	41499	53.43
21 - 30	15952	20.54	24008	30.91
11 - 20	7772	10.01	8056	10.37
01 - 10	283	0.36	284	0.37
00 - 00	1	0.00	1	0.00

Table 4

Table 4 shows the distribution of marks of candidates in each class interval. For an example, number of candidates who obtained marks in 31 – 40 class interval is 17491. It is 25.52% of the total number of candidates who sat for this subject. The cumulative frequency of this class interval is 41499. That means the number of candidates who have obtained 40 or less than 40 mark is 41499. It is 53.43%, of the total number of candidates.

1.3 Analysis of Subject Achievement

1.3.1 Achievement for Question Paper I

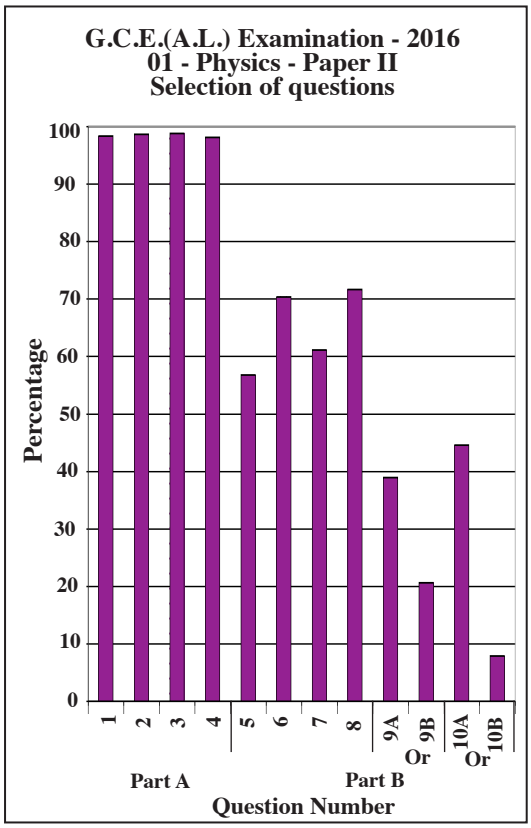


Graph 1 (prepared by the data obtained from RD/16/05/AL form)

This graph shows the facility index of each question of the paper I. If the facility index of a question has a higher value, it indicates that large number of students have chosen correct answer to the corresponding question.

Eg: A highest number of candidates have answered correctly for the question number 1. The facility index of that question is 80%.
A least number of candidates have answered correctly for the question number 31. The facility index of that question is 12%.

1.3.2 Selection of questions in question paper II

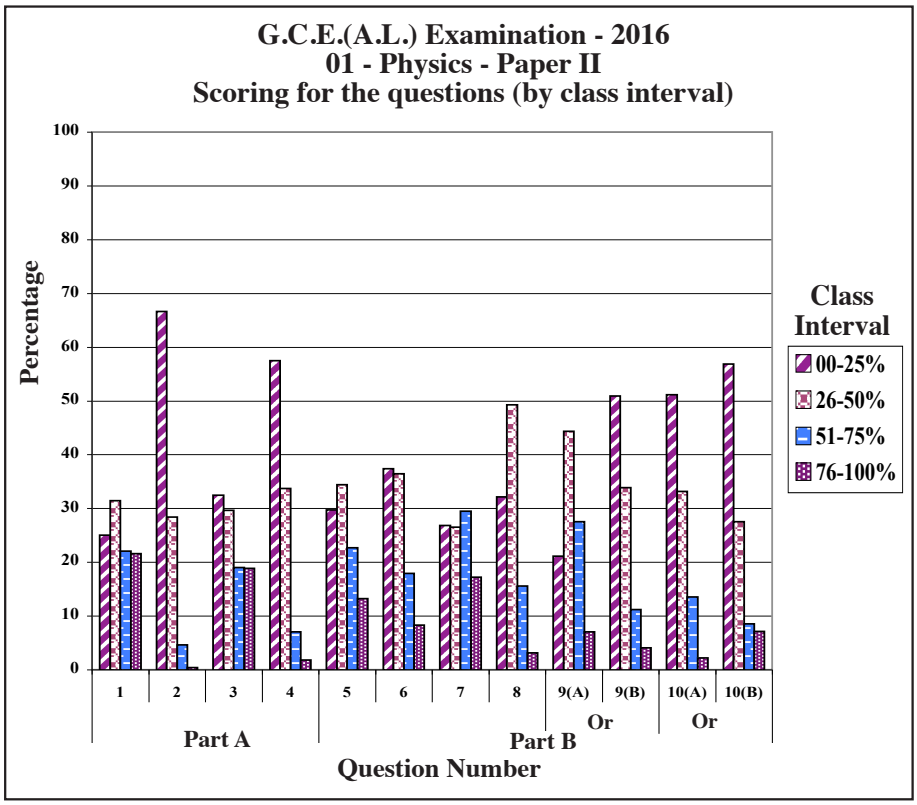


Graph 2 (Prepared using the information collected from the form RD/16/02/AL)

Percentage of students who had selected each question in paper II is shown in this graph. Although the questions from 1 to 4 are compulsory, a few students had not answered for those question. Only 98% of the students have answered.

Out of the questions from 5 to 10 in part B. majority had selected question number 8 and minority had selected number 10(B). The percentages of selecting the above two questions are 72% and 8% respectively.

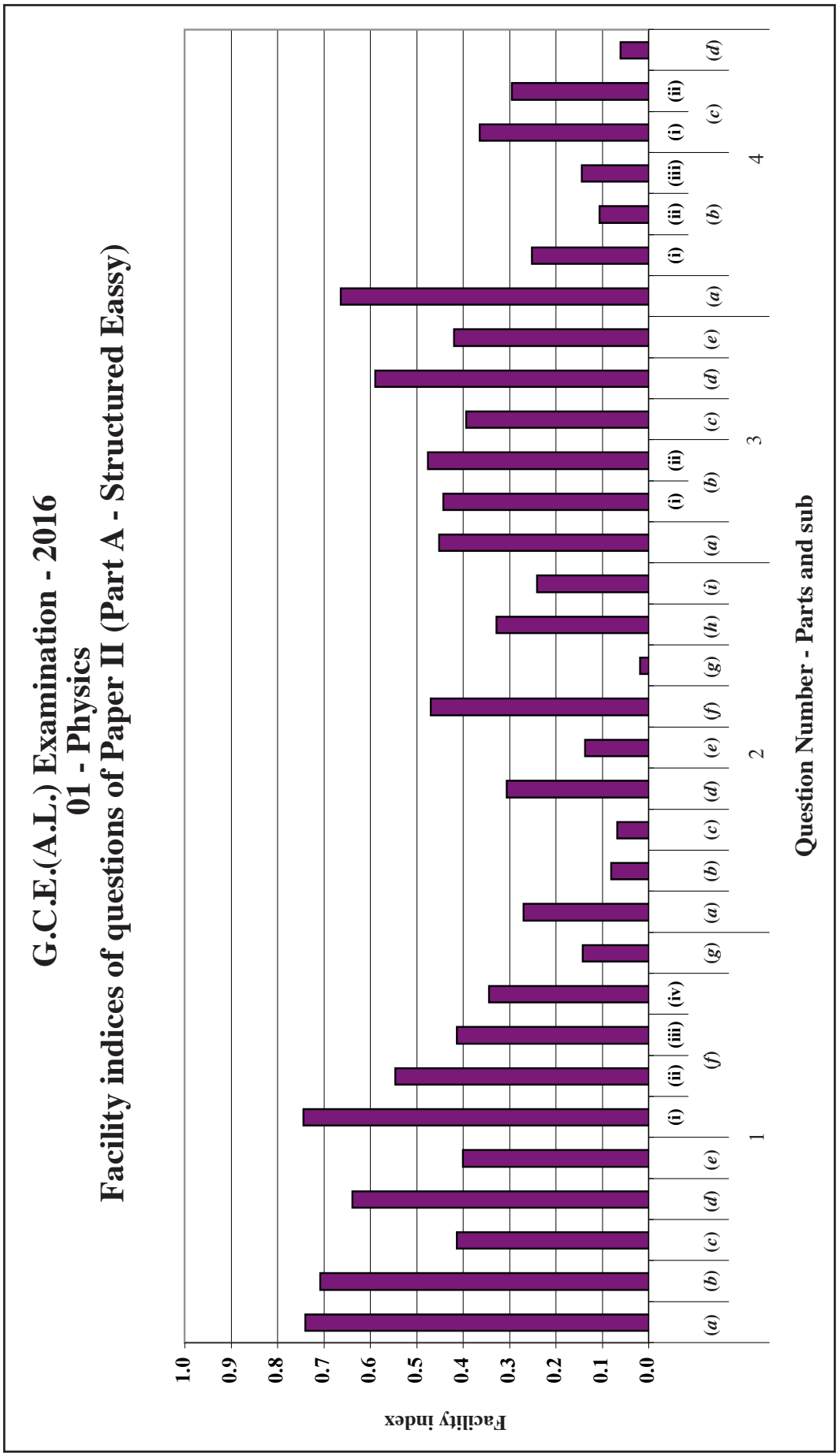
1.3.3 Scoring for the questions in paper II



Graph 3 (Prepared using the information collected from the form RD/16/02/AL)

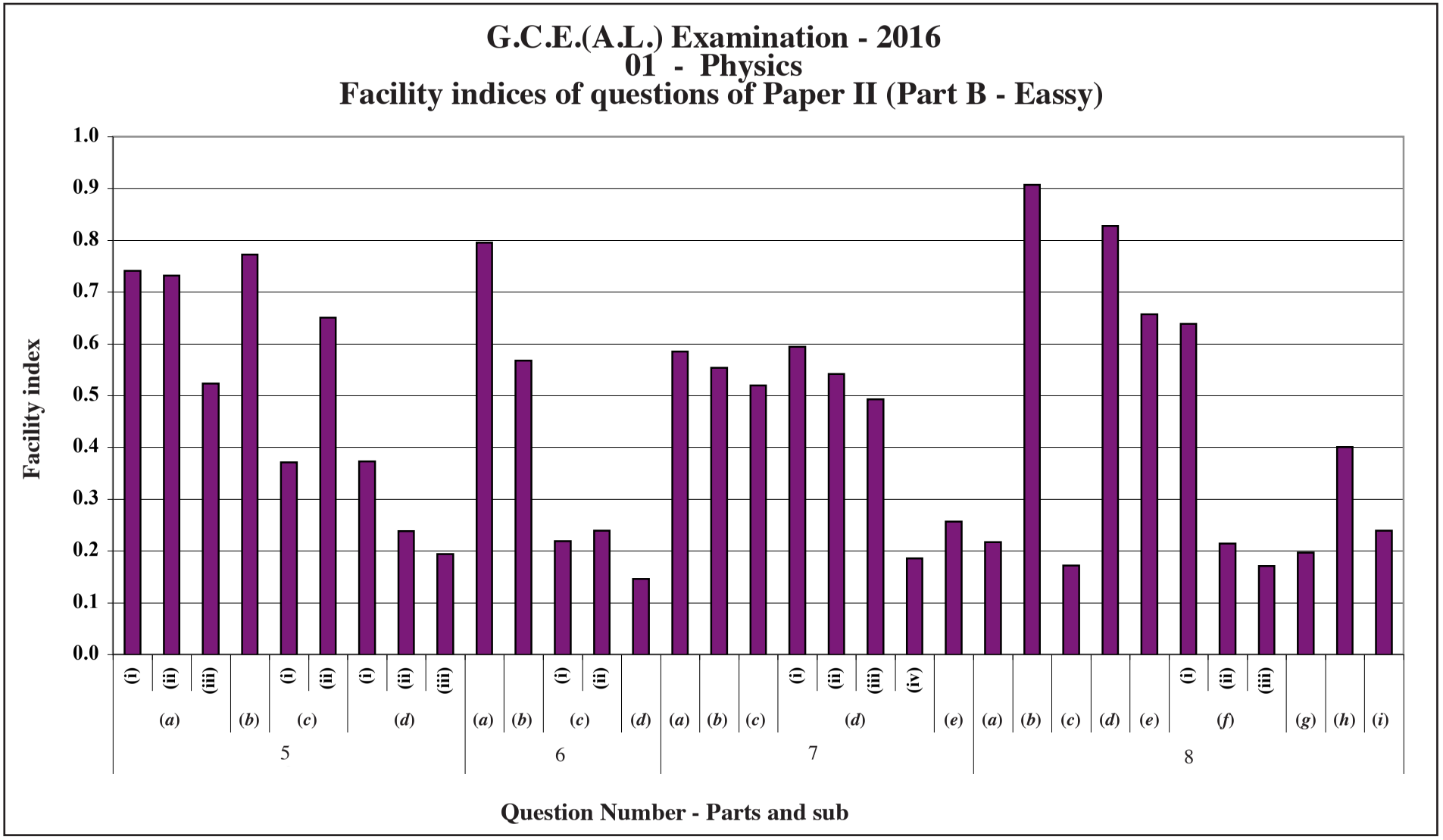
Marks allocation for each compulsory question which are question numbers 1,2,3 and 4 is 10. For example percentage of students who have obtained 76%-100% for the question number 1 is 22%. Further 22% of the student have obtained 6-7 marks or 51%-75% marks, 31% of the students have obtained 3-5 marks or 26%-50% marks and 25% of the students have obtained 0-2 marks or 0%-25% marks for the same question. Marks allocation for each of the optional questions, question number 5, 6, 7, 8, 9A, 9B, 10A and 10B is 15. For example if the question number 5 is considered, percentage of students who have have obtained 12-15 marks or 76%-100% of marks is 13%, 8-11 marks or 51%-75% of marks 23%, 4-7 marks or 26%-50% of marks is 35% and marks 0-4 or 00%-25% of marks is 30%.

1.3.4 Achievement for Question Paper II



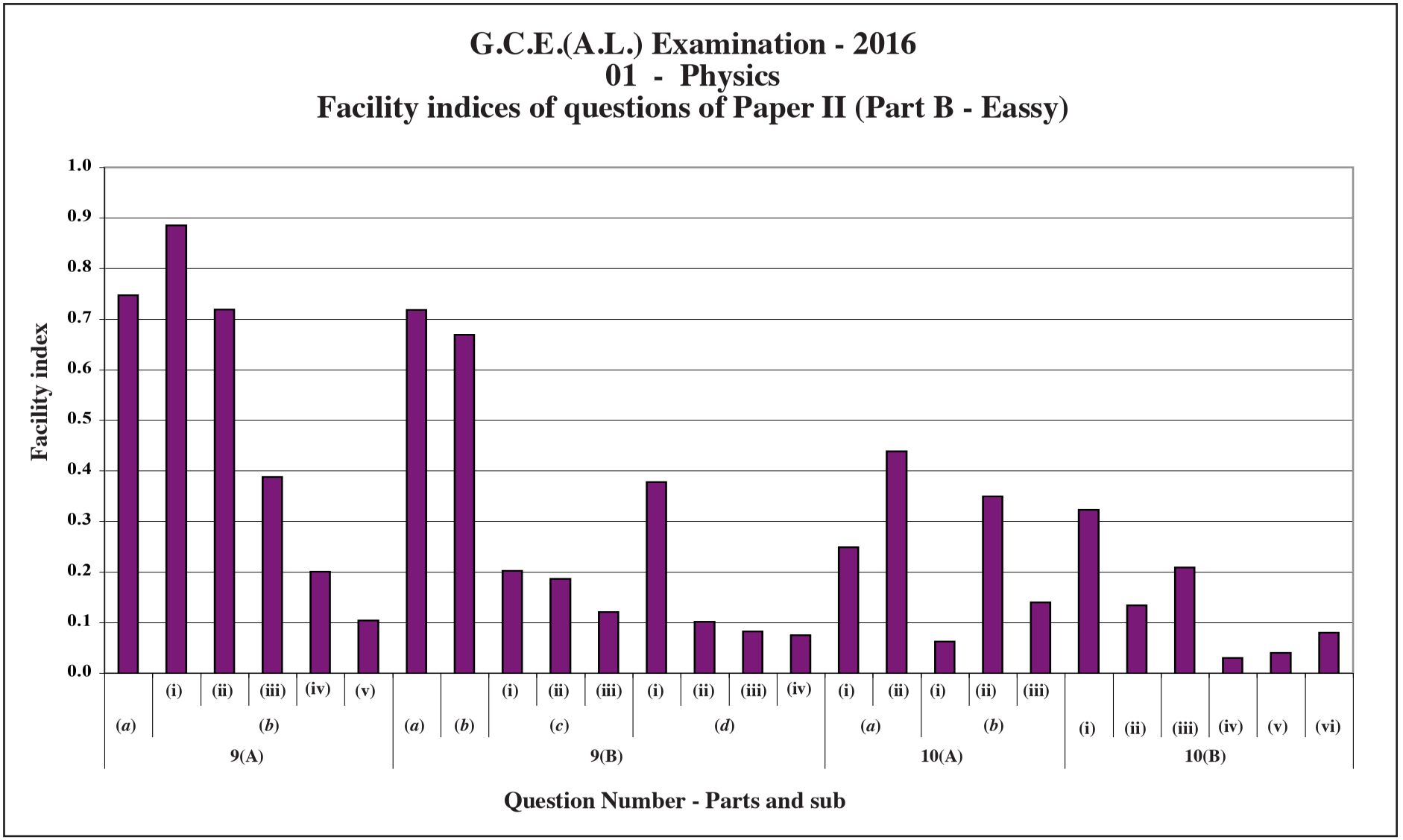
Graph 4.1 (Prepared using the information collected from the form RD/16/04/AL)

Facility indices of of each part of each question in Part A in paper II (Structured Essay) are shown in the graph. For example facility index of part (*d*) in question number 1, is 64 % and that of part (*e*) is 40 %.



Graph 4.2

Facility index of each part in question numbers from 5 to 8 of Part B in paper II (Essay) is shown in the graph. For example facility index of part (*a*) in question number 7 is 58 % and that of part (*c*) is 52 %.



Graph 4.3

Facility index of each part in question numbers from 9(A) to 10(B) of Part B in paper II (Essay) is shown in the graph. For example facility index of part (*a*)(i) in question number 10(A) is 25 % and that of part (*a*) (ii) is 44 %.

Part II

2. Information on questions and answering

2.1 Information on Question paper I and answering to paper I

2.1.1 Structure of the question paper I

- ⋆ Time : 02 hours.
- ⋆ 50 multiple choice questions with 5 options.
- ⋆ All questions should be answered.
- ⋆ Each question carries 02 marks, then Total marks will be : 100.

2.1.2. Paper I

1. The SI unit used to measure the activity of a radioactive source is
   (1) Bq (2) Gy (3) J Bq^{-1} (4) Bq^{-1} (5) Sv

2. The percentage error of a certain length measurement has to be kept below 1%. If the error due to the measuring instrument is 1 mm, the measuring length has to be greater than
   (1) 1 mm (2) 1 cm (3) 10 cm (4) 1 m (5) 10 m

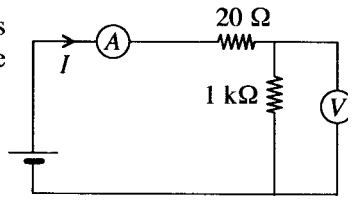
3. A certain liquid-in-glass thermometer with a uniform bore radius has been calibrated using the boiling point of water and the melting point of ice. Of the following properties, what is the **most essential** property that a thermometric liquid used in this thermometer must possess?
   (1) high volume expansivity
   (2) uniform volume expansion
   (3) high thermal conductivity
   (4) low specific heat capacity
   (5) low vapour pressure

4. Which of the following is **not true** regarding electromagnetic waves?
   (1) Directions of electric and magnetic fields are perpendicular to each other.
   (2) Speed does not depend on the medium of propagation.
   (3) Do not necessarily require a material medium for propagation.
   (4) Direction of propagation of the wave is perpendicular to the directions of electric and magnetic fields.
   (5) Can be reflected at the boundary between two media.

5. A student has suggested the following three methods (A), (B) and (C) to increase the voltage sensitivity (V/cm) of a potentiometer wire.
   (A) Increasing the length of the wire
   (B) Connecting a resistor in series with the wire
   (C) Increasing the voltage applied across the wire
   Of the above three methods,
   (1) only A is correct.
   (2) only A and B are correct.
   (3) only B and C are correct.
   (4) only A and C are correct.
   (5) all A, B and C are correct.

6. In a certain transformer there are 360 turns in the primary coil and 30 turns in the secondary coil. Which of the following voltage conversions is done using this transformer?
   (AC = Alternating current, DC = Direct current)
   (1) 240 V AC voltage to 12 V DC voltage.
   (2) 240 V AC voltage to 2 880 V AC voltage.
   (3) 240 V DC voltage to 20 V DC voltage.
   (4) 240 V AC voltage to 20 V AC voltage.
   (5) 240 V DC voltage to 2 880 V DC voltage.

7. Of the following sets of internal resistances given, the set of internal resistances that suits best for an ammeter (*A*) and a voltmeter (*V*) to have in order to measure the current *I* and the voltage across 1 kΩ resistor of the circuit shown is



	Internal resistance of ammeter	Internal resistance of voltmeter
(1)	1 Ω	5 kΩ
(2)	5 Ω	1 kΩ
(3)	1 Ω	20 Ω
(4)	20 Ω	5 kΩ
(5)	5 Ω	50 Ω

8. Which of the following is **not** a result of surface tension?
   (1) Formation of spherical water droplets
   (2) Capillary rise of water
   (3) Ability of insects to walk on water surfaces without sinking
   (4) The excess pressure inside a soap bubble
   (5) Escaping of water molecules from water surfaces

9. Consider the following statements made about a standing wave on a stretched string.

(A) The energy does not propagate along the string.

(B) The position of a node does not vary with time.

(C) Maximum displacement achieved by each particle in the string depends on its position along the string.

Of the above statements,

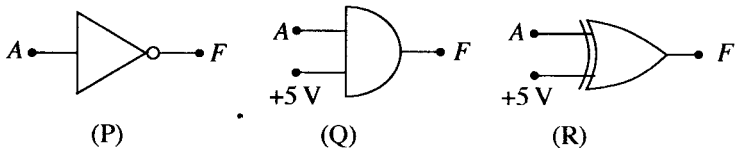
(1) only A is true. (2) only B is true.

(3) only A and C are true. (4) only B and C are true.

(5) all A, B and C are true.

10. Which of the following gates operate/s according to the truth table given?

A	F
0	1
1	0



(P) (Q) (R)

(1) P only (2) P and Q only (3) Q and R only

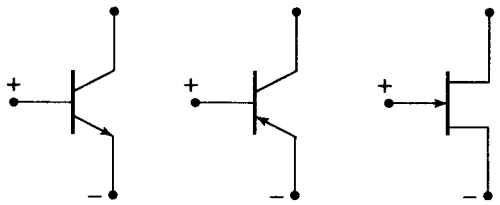
(4) P and R only (5) All P, Q and R

11. Which of the figures shown correctly indicate/s the polarities of potential difference that have to be applied across the junctions shown in order to operate the transistor properly and obtain a suitable current?

(1) in A only (2) in B only

(3) in C only (4) in A and C only

(5) in B and C only



(A) (B) (C)

12. When the body temperature of a person is 35 °C, the peak wavelength of the radiation emitted from the body occurs at 9.4 μm. If his body temperature increases to 39 °C, the peak wavelength will be (Assume that the black body radiation conditions can be applied)

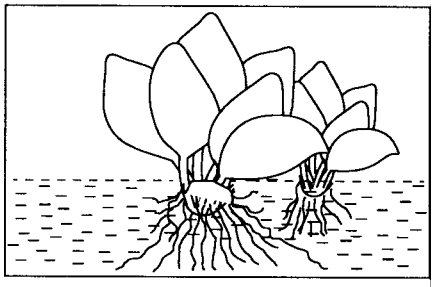
(1) $\frac{35}{39} \times 9.4\ \mu m$ (2) $\frac{39}{35} \times 9.4\ \mu m$ (3) $\frac{77}{78} \times 9.4\ \mu m$

(4) $\frac{78}{77} \times 9.4\ \mu m$ (5) $\left(\frac{78}{77}\right)^4 \times 9.4\ \mu m$

13. A moving jet plane can create a maximum sound intensity level of 150 dB. Take the sound intensity at the threshold of hearing as 10^{-12} W m^{-2}. The maximum intensity of the sound that can be created by the jet plane in W m^{-2} is

(1) 100 (2) 200 (3) 400 (4) 800 (5) 1 000

14. When wind blows over the surface of a still lake, a bunch of water hyacinth floating on water as shown in figure is observed to move in the direction of the wind with a velocity v. Consider the following statements made about v.



(A) Magnitude of v depends on the rate at which the momentum is transferred from air molecules to the bunch.

(B) Magnitude of v depends on the viscosity of water.

(C) Magnitude of v depends on the mass of the bunch.

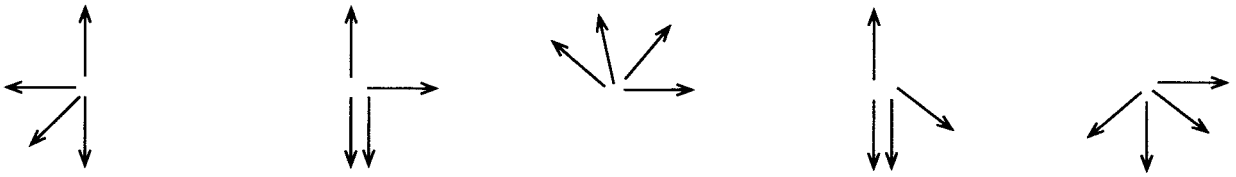
Of the above statements,

(1) only C is true. (2) only A and B are true.

(3) only B and C are true. (4) only A and C are true.

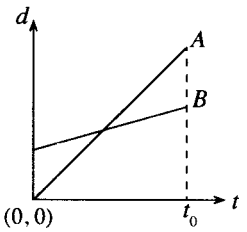
(5) all A, B and C are true.

15. An object falling down vertically in air suddenly explodes into four pieces. Which of the following diagrams shows the possible **directions** of motion of the pieces immediately after the explosion? (↓ - direction of the object before explosion)



(1) (2) (3) (4) (5)

16. The two straight lines shown in the displacement (d) – time (t) graph represent the motions of two objects A and B started from rest at time $t = 0$ and moving along the positive x-direction. Which of the following statements made about the motions of the objects is true?



(1) The object A has travelled for a longer time than B.
(2) When $t = t_0$ object B has made a displacement greater than A.
(3) Object A has a greater velocity than B.
(4) Object A has a greater acceleration than B.
(5) Both objects have the same velocity at the point where the two straight lines cross each other.

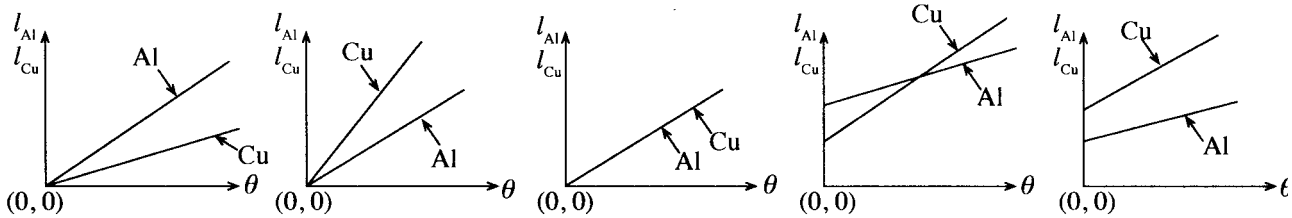
17. An elevator of weight 5000 N carries a load of 5000 N. While moving vertically upwards in a building, it travels at constant velocity from 2nd floor to 12th floor in 20 seconds. The height of each floor is 4 m. If only 80% of the power generated by the motor is consumed to lift the elevator and the load against gravity while moving at constant velocity, the power of the motor is

(1) 20 kW (2) 25 kW (3) 40 kW (4) 60 kW (5) 1 000 kW

18. Three monochromatic light beams A, B and C have the same intensities (i.e. energy flow through unit area per second). However, the wavelength associated with beam A is longer than that of B, and the frequency associated with beam C is smaller than that of A. The photon flux (number of photons crossing a unit area per second) of three beams when written in the ascending order, it will be

(1) C, A, B (2) B, A, C (3) A, B, C (4) B, C, A (5) C, B, A

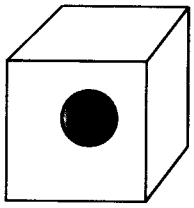
19. l_{Al} and l_{Cu} respectively represent **fractional increase** in the original lengths of two rods of aluminium (Al) and copper (Cu) when their temperature is increased by an amount of θ °C from the room temperature. Which of the following graphs best represents the variations of l_{Al} and l_{Cu} with θ °C? (Linear expansivities of aluminium and copper are 2.3×10^{-5} °C^{-1} and 1.7×10^{-5} °C^{-1} respectively.)



20. During the recent hot season, the night time temperature of a certain room with closed windows in a house made of bricks was observed to be 35 °C. A person opened the windows of the room for a few minutes at night and allowed the room to be filled with cooler air at 27 °C which was present outside the house. Once the windows were closed again, he observed that the temperature of the room had returned almost to 35 °C in a quick time. Which of the following reasons he had proposed to explain the observed effect is most **unlikely** to be accepted?

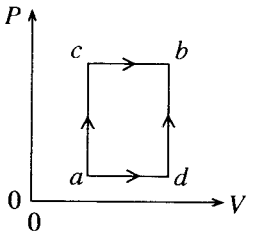
(1) Rapid movement of air molecules inside the room
(2) Collision of air molecules with the walls
(3) Low specific heat capacity of air
(4) Low thermal conductivity of air
(5) High specific heat capacity of brick walls

21. A cube of ice of mass 1 kg at 0 °C has a small metal sphere trapped inside as shown in the figure. It was found that this ice cube requires 300 kJ of heat energy to completely melt and form water at 0 °C. Specific latent heat of fusion of ice is 330 kJ/kg. The mass of the metal sphere in grams is approximately



(1) 30 (2) 33 (3) 91
(4) 110 (5) 333

22. An ideal gas is taken from state a to state b through two paths acb and adb as shown in the $P - V$ diagram. When going through path acb, 100 J of heat is absorbed and 50 J of work is done by the gas. If the work done by the gas, when taking the path adb is 10 J, the amount of heat absorbed by the gas during the path adb is



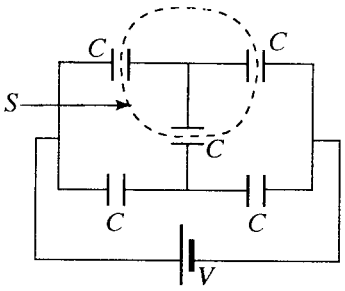
(1) 40 J (2) 50 J (3) −50 J
(4) 60 J (5) −60 J

23. If the ratio, $\frac{\text{mass of the planet}}{\text{radius of the planet}}$ for planet A is four times that of planet B, then the ratio

$\frac{\text{Escape velocity at the surface of Planet } A}{\text{Escape velocity at the surface of Planet } B}$ is

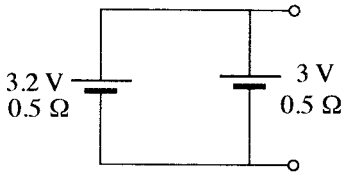
(1) $\sqrt{2}$ (2) 2 (3) 4 (4) 8 (5) 12

24. A network consisting of five identical parallel plate capacitors of capacitance C each, is connected to a cell of voltage V as shown in the figure. Assume that the capacitor plates are in free space. The net electric flux through the enclosed surface S is



(1) $\frac{CV}{2\in_0}$ (2) $\frac{3CV}{5\in_0}$ (3) $\frac{CV}{\in_0}$
(4) $\frac{3CV}{\in_0}$ (5) 0

25. Two cells having e.m.f.s of 3 V and 3.2 V and equal internal resistances of 0.5 Ω are connected in parallel as shown in figure.



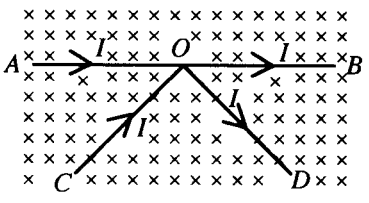
Power dissipation by the cell combination is

(1) 0.01 W (2) 0.02 W (3) 0.03 W
(4) 0.04 W (5) 0.05 W

26. Nine identical wires made of a certain metal, each of diameter d and length L, are connected in parallel to form a single resistor. The resistance of this resistor is equal to the resistance of a single wire of length L and diameter D made of the same metal if D is equal to

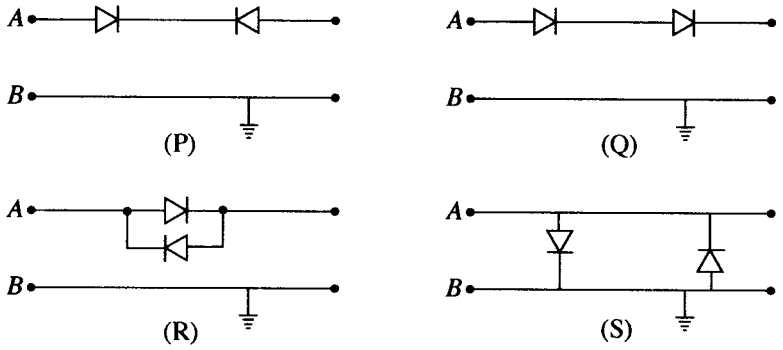
(1) $\frac{d}{3}$ (2) $3d$ (3) $6d$ (4) $9d$ (5) $18d$

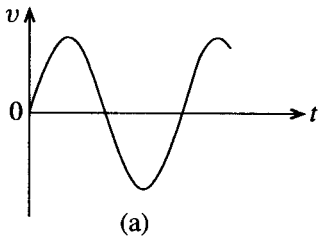
27. A structure consisting of straight wire sections of AO, OB, CO and OD of equal lengths arranged so that $A\hat{O}C = B\hat{O}D$, carry currents I along the directions shown. When this structure is placed perpendicular to a magnetic field as shown in the figure, due to magnetic field it will experience



(1) a resultant force along the plane of the paper in the upward direction.
(2) a resultant force along the plane of the paper in the downward direction.
(3) a resultant force along the plane of the paper to the right.
(4) a resultant force along the plane of the paper to the left.
(5) no resultant force.

28. The waveform shown in figure (a) is applied across the input terminals *A*, *B* of the circuits P, Q, R and S shown below.

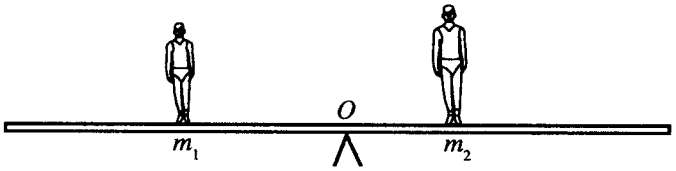




If the potential drops across the diodes are negligible, the input waveform will travel unaffected through

(1) the circuit P only. (2) the circuit Q only. (3) the circuit R only.
(4) the circuit S only. (5) the circuits R and S only.

29. Two children of masses m_1 and m_2 are standing in equilibrium as shown in figure, on a uniform rod which is balanced at its centre of gravity *O*. Then they start moving simultaneously on the rod at constant speeds v_1 and v_2 respectively while maintaining the horizontal equilibrium of the rod. Consider the following statements made about the motion of the two children.



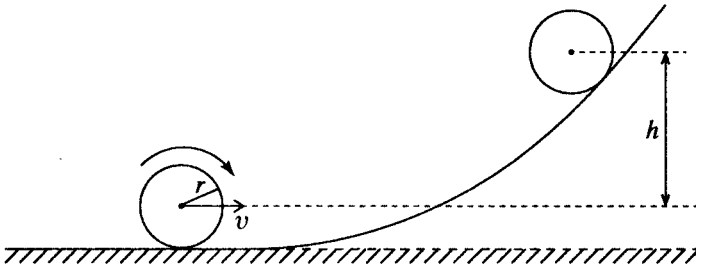
For the equilibrium to be maintained at any time *t*,

(A) they should always move in opposite directions.
(B) they should move keeping their total linear momentum always equal to zero.
(C) they should move so that the moment produced by one child about *O* is always equal and opposite to the moment produced by the other child about *O*.

Of the above statements,

(1) only A is true. (2) only B is true.
(3) only A and B are true. (4) only B and C are true.
(5) all A, B and C are true.

30. A uniform disc of mass *m* and radius *r* rolls without slipping, initially along a horizontal surface, and subsequently starts to climb up a ramp as shown in the figure. The disc has a linear velocity *v* on the horizontal surface. The moment of inertia of the disc about the axis through its centre and normal to the plane of the disc is $\frac{mr^2}{2}$. What is the maximum height *h* to which the centre of mass of the disc climb?



(1) $\frac{v^2}{2g}$ (2) $\frac{3v^2}{2g}$ (3) $\frac{3v^2}{4g}$ (4) $\frac{v^2}{g}$ (5) $\frac{2v^2}{g}$

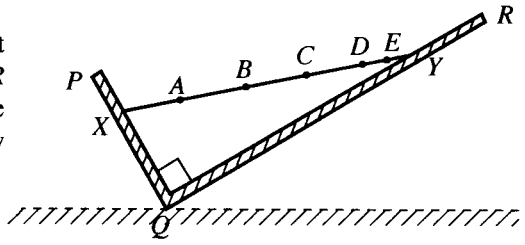
31. A glass of fresh orange solution of volume 500 cm^3 contains a few orange seeds at its bottom. It was observed that the seeds just began to float at the bottom when 10 grams of sugar was dissolved in the solution. Assume that the addition of sugar does not alter the volume of the solution. If the density of the orange solution before adding sugar was 1 000 kg m^{-3}, the density of orange seeds (in kg m^{-3}) is approximately equal to

(1) 1 020 (2) 1 040 (3) 1 060 (4) 1 080 (5) 1 100

32. A boy, sitting on a smooth turntable with a weight in his each extended hand, is rotating with an angular velocity ω_0. When he bends his hands towards his body, the angular velocity becomes ω_1. If I_0 and I_1 are the moments of inertia of rotating systems when the hands are extended, and bent towards his body respectively, then

(1) $\omega_0 > \omega_1$, $I_0 > I_1$ and $\omega_0 I_0 > \omega_1 I_1$ (2) $\omega_0 < \omega_1$, $I_0 > I_1$ and $\omega_0 I_0 < \omega_1 I_1$
(3) $\omega_0 < \omega_1$, $I_0 > I_1$ and $\omega_0 I_0 = \omega_1 I_1$ (4) $\omega_0 > \omega_1$, $I_0 < I_1$ and $\omega_0 I_0 = \omega_1 I_1$
(5) $\omega_0 = \omega_1$, $I_0 = I_1$ and $\omega_0 I_0 = \omega_1 I_1$

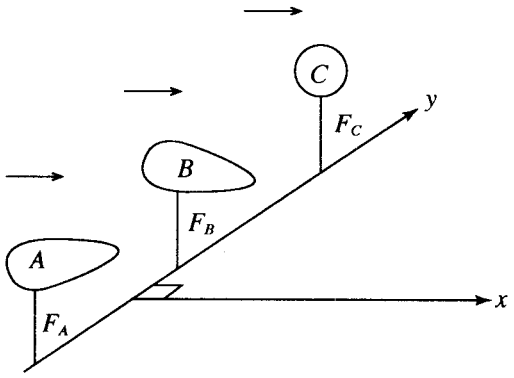
33. A rod XY rests between two smooth boards PQ and QR kept inclined to the horizontal as shown in the figure. Angle PQR is 90° and the surfaces of the boards are normal to the plane of the paper. The centre of gravity of the rod is most likely to be situated at the point



(1) A (2) B (3) C
(4) D (5) E

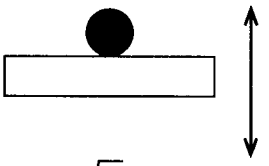
34. Two objects A and B of the shapes shown in the figure, and a spherical object C, all having identical masses, are mounted rigidly on a horizontal surface along the y–axis by three thin rods as shown in the figure. Both x and y axes are located on the horizontal surface.

A stream of air flows through the objects parallel to the surface and along x-direction. (Assume that the air flow causes no turbulence around the objects.) The magnitudes of the forces F_A, F_B and F_C exerted by the objects and the sphere on the mounted rods, when written in the ascending order, it will be



(1) F_B, F_A, F_C (2) F_B, F_C, F_A (3) F_C, F_A, F_B
(4) F_A, F_C, F_B (5) F_C, F_B, F_A

35. A mass is resting on a horizontal surface which moves up and down performing simple harmonic motion with amplitude A as shown in figure. The maximum frequency with which the surface can move while keeping the mass always in contact with the surface is

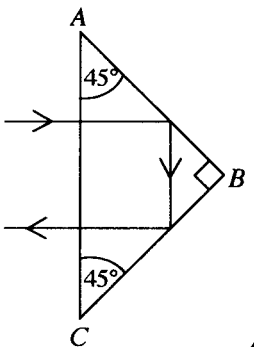


(1) $2\pi\sqrt{\frac{g}{A}}$ (2) $\sqrt{\frac{g}{A}}$ (3) $\frac{1}{2}\sqrt{\frac{g}{A}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{g}{A}}$ (5) $\frac{1}{\pi}\sqrt{\frac{g}{A}}$

36. A whistle emitting a sound of frequency f moves along the circumference of a circle of radius r at a constant angular velocity ω. v is the velocity of sound in air. The highest frequency of sound heard by a listener, who is at rest outside the circle is

(1) $f\left(\frac{v}{v-r\omega}\right)$ (2) $f\left(\frac{v-r\omega}{v}\right)$ (3) $f\left(1-\frac{v}{r\omega}\right)$ (4) $f\left(\frac{v}{r\omega}\right)$ (5) $f\left(\frac{v}{v+r\omega}\right)$

37. A ray of light is incident perpendicular to the surface AC of a right angled glass prism as shown in the figure. Minimum value of the refractive index of the material of the prism for which the ray will follow the path shown is

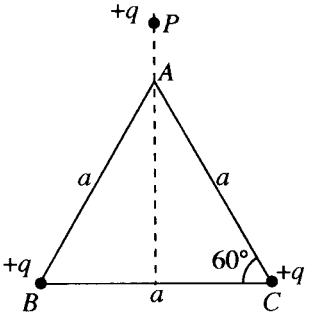


(1) 1.22 (2) 1.41 (3) 1.58
(4) 1.73 (5) 1.87

38. When an object is placed on the principal axis of a thin convex lens of focal length f_1, it forms a real image at a distance V_1 with a linear magnification of m_1. When this lens is replaced by another thin convex lens of focal length f_2, $(f_2 < f_1)$, being kept at the same position the new image distance V_2 and the magnification m_2 will satisfy the conditions,

(1) $V_2 > V_1$ and $m_2 > m_1$
(2) $V_2 > V_1$ and $m_1 > m_2$
(3) $V_2 < V_1$ and $m_2 > m_1$
(4) $V_2 < V_1$ and $m_1 > m_2$
(5) $V_2 < V_1$ and $m_1 = m_2$

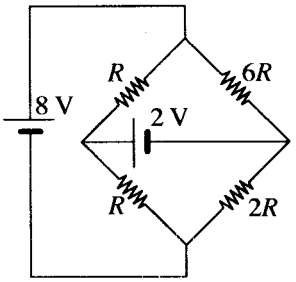
39. Two point charges of $+q$ each, are held at vertices B and C of an equilateral triangle ABC of side length a, and another point charge of $+q$ is held at the point P as shown in the figure. A zero resultant force will act on a positive unit charge placed at point A when the distance AP is equal to



(1) $\sqrt{2}a$ (2) $\frac{a}{2}$ (3) $\frac{a}{\sqrt{(\sqrt{3})}}$

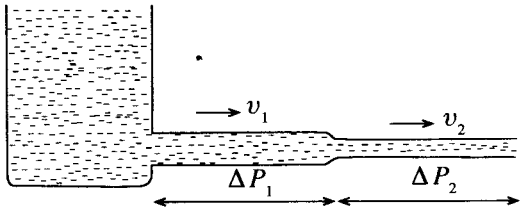
(4) $\frac{a}{4}$ (5) a

40. In the circuit shown, the two cells have negligible internal resistances. In the circuit,



(1) a current of $\frac{3}{2R}$ passes through the 2 V cell.
(2) a current of $\frac{6}{R}$ passes through the 2 V cell.
(3) a current of $\frac{10}{R}$ passes through the 2 V cell.
(4) a current of $\frac{3}{R}$ passes through the 2 V cell.
(5) a current does not pass through the 2 V cell.

41. Two narrow tubes of equal lengths but different radii of cross-section are connected end to end, and water is allowed to flow through it as shown in the figure.

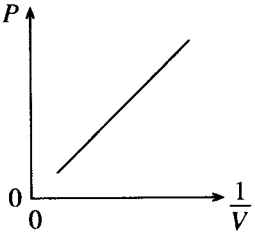


If v_1 and v_2 are the average velocities with which water flows through cross-sections of the tubes, and ΔP_1 and ΔP_2 are the pressure differences built up across the tubes as shown, then the ratio, $\frac{\Delta P_1}{\Delta P_2}$ is equal to

(1) $\left(\frac{v_1}{v_2}\right)^{\frac{1}{4}}$ (2) $\frac{v_1}{v_2}$ (3) $\left(\frac{v_1}{v_2}\right)^2$ (4) $\left(\frac{v_1}{v_2}\right)^3$ (5) $\left(\frac{v_1}{v_2}\right)^4$

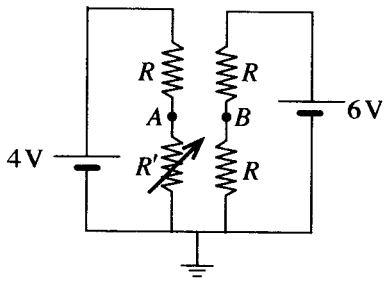
42. A student performed an experiment to verify the Boyle's Law using a constant mass m_0 of an ideal gas at the room temperature of 27 °C and obtained the graph given in the figure. Here P is the pressure and V is the volume of the gas.

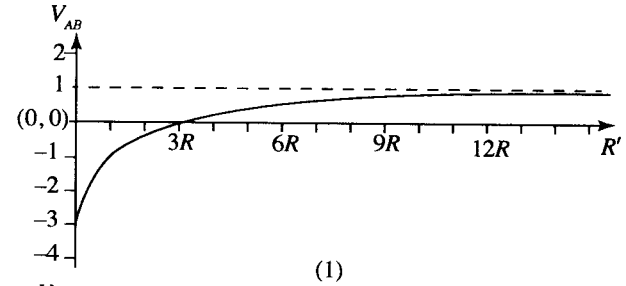
He then removed a certain amount of gas from the volume V and repeated the experiment at a temperature 100 °C above the room temperature. If the new graph he obtained has the same gradient as the graph shown in the figure, the mass of the gas that he had removed is



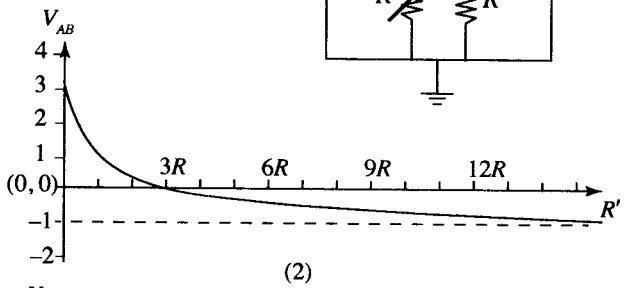
(1) $\frac{27}{100}m_0$ (2) $\frac{73}{100}m_0$ (3) $\frac{1}{4}m_0$ (4) $\frac{1}{2}m_0$ (5) $\frac{3}{4}m_0$

43. In the circuit shown, both cells have negligible internal resistances. R' is the value of a variable resistor. Variation of the voltage V_{AB} $(= V_A - V_B)$ across the points A and B with R' is best represented by

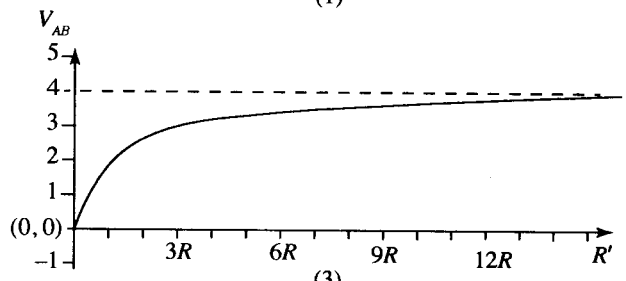




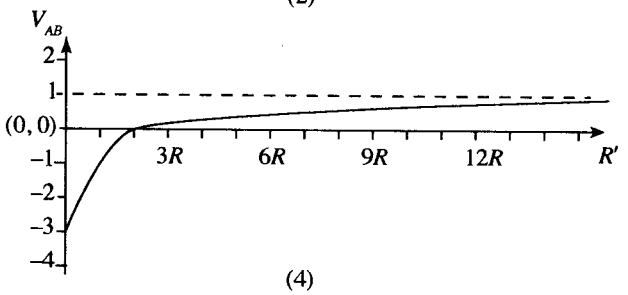
(1)



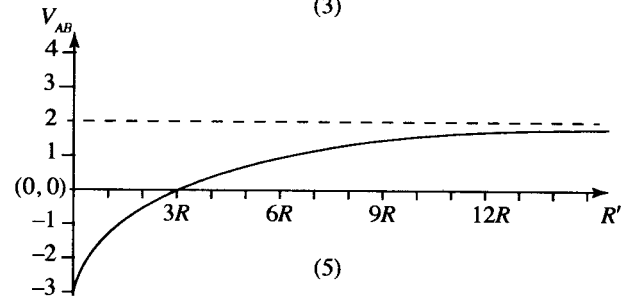
(2)



(3)

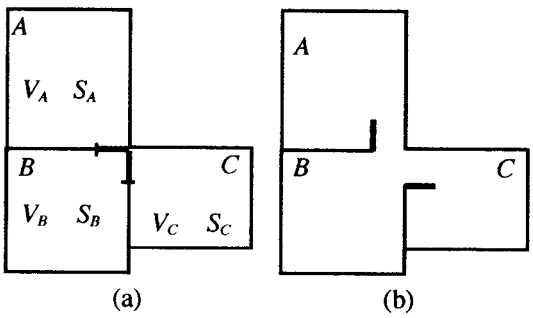


(4)



(5)

44. Absolute humidities of air inside three closed rooms A, B and C of volumes V_A, V_B and V_C at atmospheric pressure are S_A, S_B and S_C respectively. [See figure (a)]. The dew point of air in room A is T_0. When the doors are opened as shown in figure (b) and the air in three rooms are allowed to mix, the common dew point of the three rooms will remain at T_0 if



(a) (b)

(1) $S_A = \dfrac{V_B S_B + V_C S_C}{V_B + V_C}$

(2) $S_A = \dfrac{S_B + S_C}{2}$

(3) $V_A S_A = V_B S_B + V_C S_C$

(4) $\dfrac{S_A}{V_A} = \dfrac{S_B}{V_B} + \dfrac{S_C}{V_C}$

(5) $S_A = \sqrt{S_B S_C}$

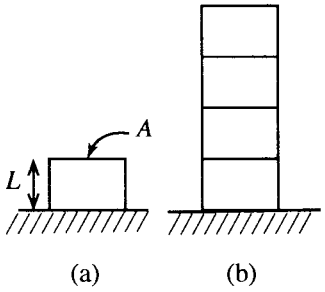
45. A 2 μF capacitor and a 1 μF capacitor are connected in series and charged by a battery. Then the stored energies of the capacitors are E_1 and E_2 respectively. When they are disconnected, allowed to discharge, and charged again **separately** using the same battery, the stored energies of the two capacitors are E_3 and E_4 respectively. Then

(1) $E_3 > E_1 > E_4 > E_2$
(2) $E_1 > E_2 > E_3 > E_4$
(3) $E_3 > E_1 > E_2 > E_4$
(4) $E_1 > E_3 > E_4 > E_2$
(5) $E_3 > E_4 > E_2 > E_1$

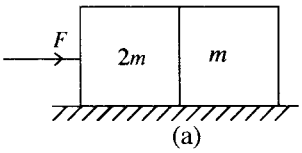
46. The height of a rectangular heavy metal block of mass M, area of cross-section A, and made of a material of Young's modulus Y, when placed on a horizontal surface as shown in figure (a) is L. If four blocks identical to the above mentioned block are stacked together as shown in figure (b), the overall height of the four blocks will be

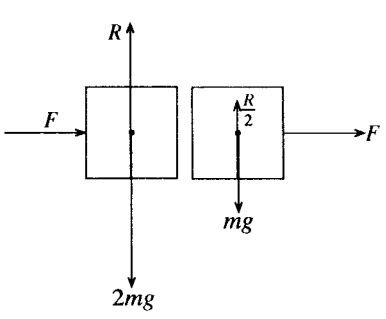
(1) $L\left(4-\frac{2Mg}{YA}\right)$ (2) $L\left(4-\frac{8Mg}{YA}\right)$ (3) $L\left(4-\frac{7Mg}{YA}\right)$

(4) $L\left(4-\frac{6Mg}{YA}\right)$ (5) $L\left(4-\frac{4Mg}{YA}\right)$

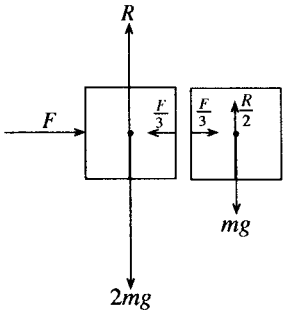


47. Two blocks of mass $2m$ and m are placed in contact on a smooth surface as shown in the figure (a). If an external horizontal force F is applied on the block of mass $2m$, which of the following figures shows the forces acting on the two blocks correctly?

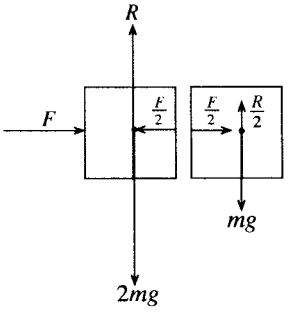




(1)



(2)



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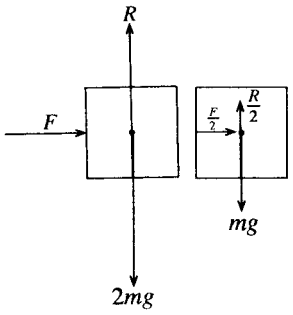
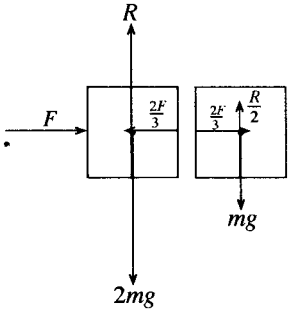


(4)



(5)

48. As shown in the figure, a rectangular wire loop $ABCD$ is inserted perpendicular to a uniform magnetic field confined to a region $PQRS$ from position 1 and taken across the field with a constant velocity v. It passes through position 2 and finally taken out of the magnetic field at position 3 with the same velocity. Which of the following statements is **not true**?

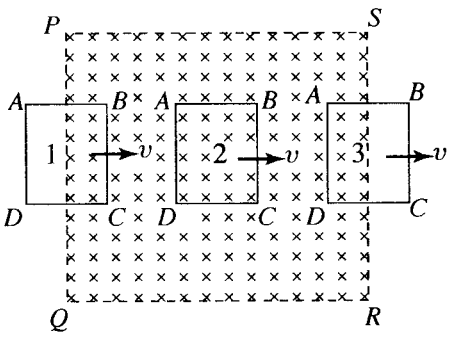
(1) When the loop passes through position 1, a constant e.m.f. will be induced only across section BC of the wire loop.

(2) As the loop passes through position 2, constant e.m.f.s will be induced across AD and BC, and they are equal and opposite to each other.

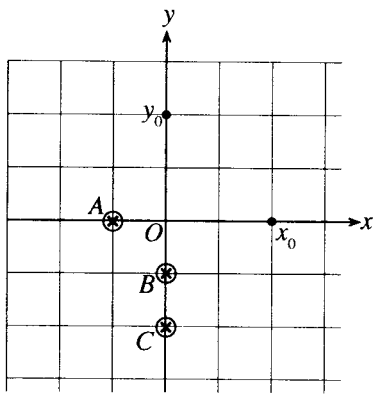
(3) At position 3, a constant e.m.f. will be induced only across AD.

(4) At position 2, the resultant force on the loop due to magnetic field is zero.

(5) The directions of the forces due to magnetic field on the loop at positions 1 and 3 are opposite to each other.

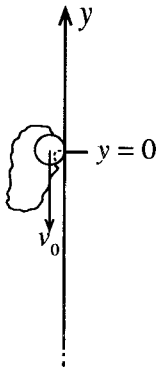


49. Three thin long and straight wires carrying equal currents I are held in fixed positions A, B and C perpendicular to the plane of the paper as shown in the figure, where OA = 1 m, OB = 1 m and OC = 2 m. Two other thin, long and straight wires are also held perpendicular to the plane of the paper, at points x_0 and y_0 where x_0 = 2 m and y_0 = 2 m. Which of the following currents set up in the wires at x_0 and y_0 will produce a resultant magnetic field of magnitude $\frac{\mu_0 I}{2\pi}$ in positive y-direction at the point O.



	Current to be set up in the wire at x_0	Current to be set up in the wire at y_0
(1)	$3I$ ⊙	$4I$ ⊗
(2)	$4I$ ⊙	$6I$ ⊙
(3)	$4I$ ⊗	$3I$ ⊗
(4)	$4I$ ⊗	$4I$ ⊙
(5)	$6I$ ⊙	$4I$ ⊙

50. A particle of mass m is attached to one end of a light elastic string of force constant k and unstreatched length of l_0. The other end of the string is fixed onto a vertical frictionless wall at $y = 0$ as shown in the figure. The particle is then projected vertically downwards from the position $y = 0$ with a velocity $v_0, \left(v_0 < \sqrt{2gl_0}\right)$. Neglect the air resistance.



After passing through its lowest point in the path, the particle will again come to rest momentarily at a point whose y coordinate is

(1) $-\frac{\left[m(v_0^2 + 2gl_0) - kl_0^2\right]}{2gm}$

(2) $-\frac{(v_0^2 + 2gl_0)}{2g}$

(3) $\frac{v_0^2 + 2gl_0}{2g}$

(4) $\frac{mv_0^2 + kl_0^2}{gm}$

(5) $\frac{v_0^2}{2g}$

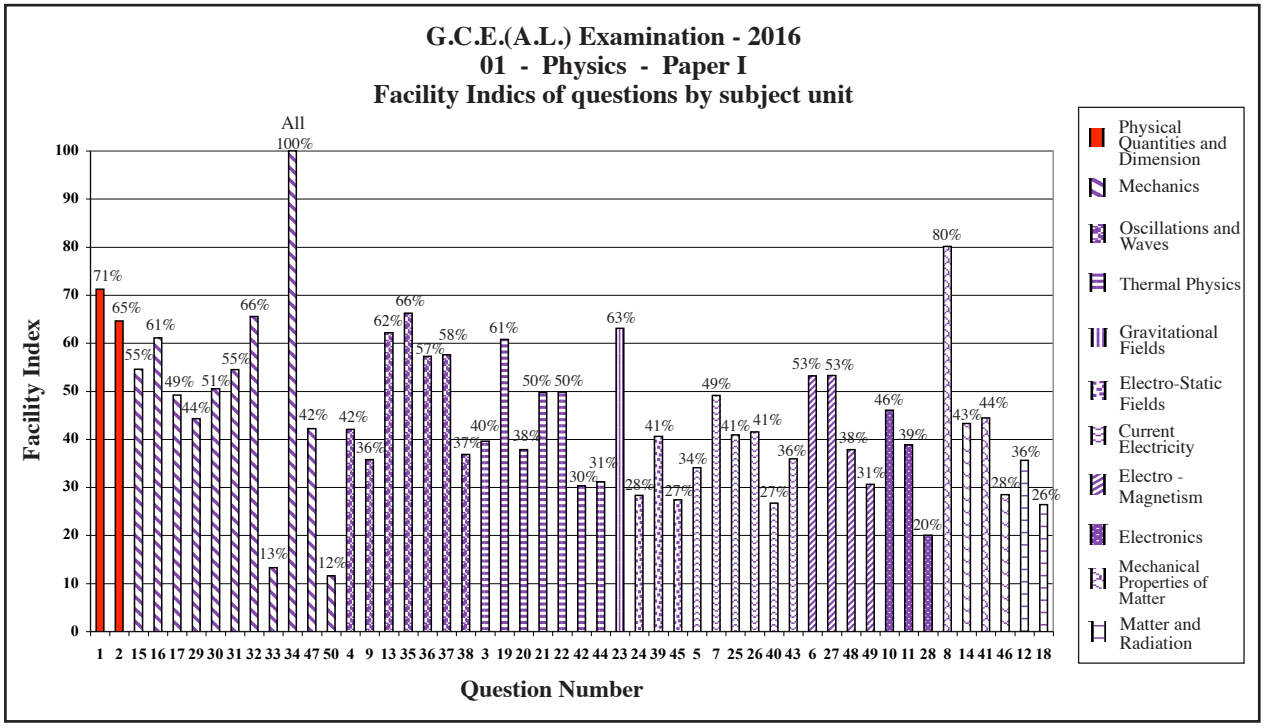
2.1.3. Expected answers and the scheme of marking for question paper I

Scheme of Marking for Paper I

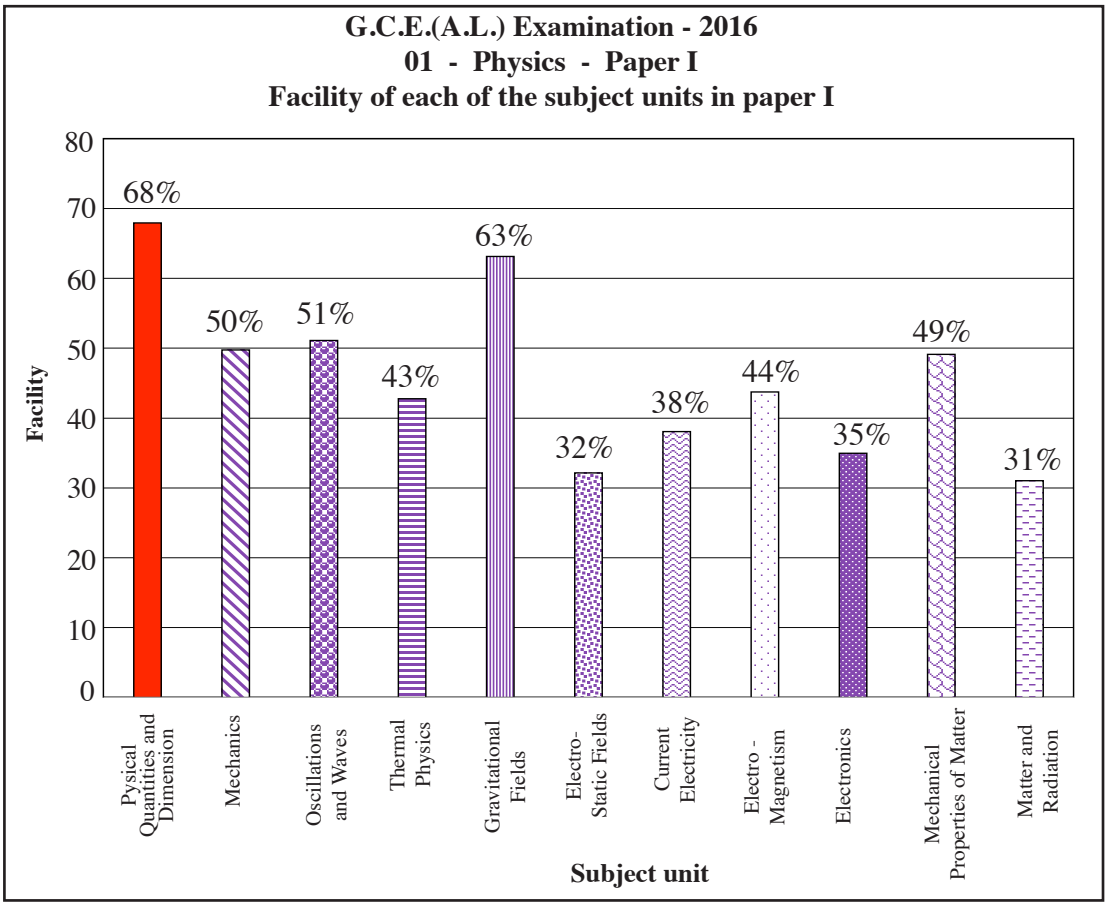
Question No.	Answer	Question No.	Answer
01.	1	26.	2
02.	3	27.	1
03.	2	28.	3
04.	2	29.	5
05.	2	30.	3
06.	4	31.	1
07.	1	32.	3
08.	5	33.	4
09.	5	34.	All
10.	4	35.	4
11.	1	36.	1
12.	3	37.	2
13.	5	38.	4
14.	5	39.	3
15.	5	40.	5
16.	3	41.	3
17.	2	42.	3
18.	2	43.	1
19.	1	44.	1
20.	4	45.	5
21.	3	46.	4
22.	4	47.	2
23.	2	48.	5
24.	5	49.	3
25.	4	50.	5

Each correct answer carries 02 marks, amounting the total to 100.

2.1.4 Observations on the responses to paper I (by subject unit) :



Subject unit		Number of Questions	Highest facility		Lowest facility	
			Question	Facility	Question	Facility
1.	Physical Quantities and Dimension	02	1	71%	2	65%
2.	Mechanics	11	32	66%	50	12%
3.	Oscillations and Waves	07	35	66%	9	36%
4.	Thermal Physics	07	19	61%	42	30%
5.	Gravitational Fields	01	23	63%	-	-
6.	Electro-Static Fields	03	39	41%	45	27%
7.	Current Electricity	06	7	49%	40	27%
8.	Electro - Magnetism	04	27	53%	49	31%
9.	Electronics	03	10	46%	28	20%
10.	Mechanical Properties of Matter	04	8	80%	46	28%
11.	Matter and Radiation	02	12	36%	18	26%



The unit, Physical Quantities and Dimension has the highest facility and of all the units and it is 68%. There were only two questions from that unit and they were simple. Therefore the facility index is higher. Question number 1, that carries the highest facility index of 71% among all the questions, is also from this unit.

The unit with the least facility is Matter and Radiation. The facility of it is 31%. There were only two questions from this unit and the highest facility of them was 43% and the lowest facility was 17%. It is evident that the comprehension regarding this unit is not sufficient.

The range of facilities of the other units is 32%-63% number of questions from Mechanics was 11, and it was the highest number of questions from a unit. Further 7 questions from the unit Oscillations and waves, 7 questions from the unit Thermal Physics and 4 questions from the unit Electromagnetism were there in the question paper I. Facility of the unit Mechanics is about 50% among the facilities of all the units.

2.1.5 Summary of observations, conclusions and suggestions about answering for the question paper I.

Question number 8 was the question with the highest facility index and it was 80%. The facilities of question number 01, 02, 32 and 35 are above 65%. Because they were based on fundamental theories and simple calculations. More than 60% of the candidates had made the correct choice for question numbers 13, 16, 19 and 23. Ability to obtain the correct answer using bacis formulae and simple calculations have lead the students towards a good achievement. The least percentage of correct responses was there for question number 50. It was 12% of the students. The facts that instant rest of a particle when it is subjected to a maximum stretching in a string and the velocity of it is v_0 upwards at $y = 0$ position, when there is no energy loss and when it is moved vertically upwards again, had not considered when writing the simple equation and thereby to obtain the answer by the students. Therefore they have failed to make the correct choice.

The students must be trained tp think logically in oder to obtain the correct answers. The facility for question number 33 was as low as 13% students should be trained well to find the centre of gravity of a rod which is in equilibrium under three forces, by marking the forces. 40% of the candidates have made the second choice. Because they have considered the centre of gravity of the system instead of the centre of gravity of the rod. Only a percentage which is as low as 28% has made the correct choice for question number 24, which is from the unit Elecrostatic fields. Poor understanding regarding the effective charge of a set of connected plates has led this situation. A lower percentage of about 20% has made the correct choice for the question number 28, which is from the unit Electronics. The is due to the lack of knowledge regarding the forward biasing and reverse biasing of a diode.

The unit Mechanical Properties of matter has the highest facility, that is 80%. Question number 8, 44 and 46 are from that unit. 71% and 65% facilities are there for question number 01 and 02, which are from the unit measurement. Question number 15, 16, 17, 29, 30, 31, 32, 33, 34, 47 and 50 are from the unit Mechanics. Facility ranges from 66% to 12% for these 11 questions.

There were 7 questions from the unit Oscillations and Waves. Facilities of those questions lie between 66% and 36%. There were 7 questions from the unit thermal physics also. Question number 19 has the highest facility. It is 61%. The question with the lowest facility from unit Termal Physics is question number 42 and it has a facility of 30%. The only question from Gravitational Fields is question number 23 and it has a facility of 63%. There were 3 questions from the unit Electro-Static fields. Facilies of them lie between 41% and 27%. There were 4 questions from the unit Electro - Magnetism and facilities of them lie between 31% and 53%. There were 6 questions from the unit Current Electricity and facilities of them lie between 49%% and 27%%. There were 2 questions from the unit Matter and Radiation and the facilities of them are 26% and 36%.

2.1.6 Selection of responses for each question in paper I (As a percentage)

Question Number	Correct Responses	Number of students selected each Response					
		1	2	3	4	5	Missing
1	1	71.21	10.92	5.42	6.62	5.46	0.37
2	3	8.60	16.64	64.60	7.44	2.47	0.25
3	2	11.81	39.59	18.65	22.50	6.95	0.50
4	2	5.79	42.02	6.54	16.19	28.93	0.53
5	2	6.39	34.06	26.36	19.10	13.42	0.67
6	4	23.36	7.07	12.67	53.20	3.29	0.41
7	1	49.12	12.93	20.79	9.76	6.54	0.86
8	5	3.55	5.68	3.55	6.84	80.15	0.23
9	5	5.50	8.07	20.04	30.13	35.74	0.52
10	4	40.82	5.68	3.85	46.02	3.33	0.30
11	1	38.84	9.20	4.71	42.36	4.11	0.78
12	3	16.79	22.13	35.59	10.62	14.21	0.66
13	5	4.41	9.76	11.85	11.03	62.13	0.82
14	5	4.45	21.31	12.90	17.64	43.29	0.41
15	5	6.77	5.53	20.00	12.45	54.58	0.67
16	3	1.98	7.81	61.12	10.32	18.50	0.27
17	2	12.82	49.20	17.61	12.67	6.73	0.97
18	2	30.09	26.43	14.77	15.10	12.86	0.75
19	1	60.79	13.35	2.99	12.41	9.87	0.59
20	4	8.41	13.27	16.00	37.87	23.74	0.71
21	3	12.04	13.94	49.72	19.36	4.00	0.94
22	4	13.98	11.74	13.20	49.83	10.39	0.86
23	2	8.37	63.10	16.90	8.67	2.43	0.53
24	5	20.04	15.36	17.35	18.28	28.30	0.67
25	4	12.04	17.20	20.00	40.90	8.71	1.15
26	2	16.75	41.50	6.36	29.98	5.05	0.36
27	1	53.23	15.18	14.43	5.68	10.92	0.56
28	3	5.53	25.08	20.00	20.90	27.81	0.68
29	5	2.84	4.67	6.54	41.27	44.26	0.42
30	3	19.85	15.63	50.50	7.48	5.76	0.78
31	1	54.50	12.79	10.88	9.20	11.29	1.34
32	3	7.96	12.04	65.53	11.78	2.28	0.41
33	4	25.91	40.07	19.29	13.27	1.16	0.30
34	All	16.56	20.56	25.38	14.95	21.57	0.98
35	4	13.94	6.17	7.78	66.21	5.05	0.85
36	1	57.27	13.20	8.15	7.36	13.53	0.49
37	2	11.14	57.53	19.18	8.45	3.07	0.63
38	4	18.65	13.98	22.77	36.82	6.92	0.86
39	3	14.54	15.93	40.60	14.95	12.79	1.19
40	5	12.90	15.85	22.80	19.29	26.73	2.43
41	3	12.37	25.23	44.45	5.98	11.44	0.53
42	3	14.50	24.00	30.28	9.57	20.67	0.98
43	1	35.89	13.20	15.29	17.79	17.35	0.48
44	1	31.18	14.84	21.53	25.50	5.76	1.19
45	5	21.76	17.27	19.40	13.42	27.40	0.75
46	4	5.35	16.30	13.46	28.45	35.21	1.23
47	2	5.35	42.24	30.28	7.14	14.47	0.52
48	5	4.67	25.23	12.00	19.29	37.87	0.94
49	3	11.78	22.32	30.62	24.11	9.83	1.34
50	5	18.06	23.66	24.45	20.97	11.55	1.31

2.2 Information on the question paper II and answering to paper II

2.2.1 Structure of the paper II

Time : 03 hours.

This question paper consists of two parts, Structured Essay and Essay.

Part **A** – Four structured essay type questions. All questions should be answered. Each question carries 10 marks. 40 marks in total.

Part **B** – Six essay type questions. Four questions should be answered. Each question carries 15 marks. 60 marks in total.

Calculation of total marks for Paper II	–	Marks for part **A**	= 40
		Marks for part **B**	= 60
		Total marks for Paper II	= 100

2.2.2 Expected answers, scheme of marking, observations on the responses, conclusions and suggestions related to question paper II

★ **Observations regarding answering the paper II are based on graphs 2, 3, 4.1, 4.2 and 4.3.**

Part A - Structured Essay

1. When certain objects are packed in containers they do not occupy the entire volume of the container. This occurs due to the shape of the objects, and under such situations a fraction of the container volume is always empty and filled with air.
Consider a container in the form of a cubical box of side length $8r$, which is fully packed with identical solid spheres of **radius** r in a regular manner as shown in figure (1). This is called **regular packing**.

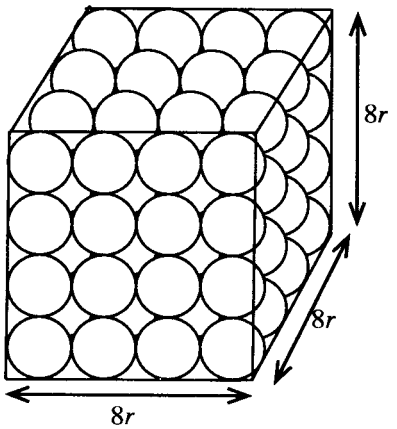


Figure (1)

(*a*) Find the number of spheres packed in the container.

64 ..... **(01)**

(*b*) Obtain an expression for the total material volume of all spheres packed in the container in terms of r and π.

$\left(\frac{4}{3}\pi r^3\right) \times 64$ **OR** $\frac{256}{3}\pi r^3$ ..... **(01)**

(*c*) When the container is completely filled with spheres, the ratio,

$\frac{\text{Total material volume of the spheres in the container}}{\text{Volume of the fully packed container}}$, is called the **packing fraction** (f_p) of the spheres and the volume of the fully packed container is called the **packed volume**.

Find the packing fraction, f_p, for the above regular packing.

$$f_p = \frac{\frac{256}{3}\pi r^3}{512r^3}$$

$$= \frac{\pi}{6} \quad \text{..... (01)}$$

(*d*) If m is the total mass of the spheres in the container, derive an expression for the ratio:

$\frac{\text{Total mass of the spheres}}{\text{Volume of the fully packed container}}$, in terms of m and r.

This ratio is called the **bulk density** (d_B) of the spheres.

$$d_B = \frac{m}{512r^3} \quad \text{..... (01)}$$

(No marks for writing 8^3 instead of 512)

(*e*) Write down an expression for the density (d_M) of the material of the spheres in terms of m, r and π.

$$d_M = \frac{m}{\frac{256}{3}\pi r^3} = \frac{3m}{256\,\pi r^3} \quad \text{..... (01)}$$

(*f*) A student has decided to find the parameters f_p, d_B and d_M for green gram using an experimental method. In this case green gram is packed in a random manner and it is called **random packing**. See figure (2). The definitions mentioned in part (*c*), (*d*) and (*e*) for f_p, d_B and d_M are valid for random packing of items of any shape too.

First he inserted dry green gram into a measuring cylinder and obtained a packed volume of 50 cm^3 of green gram as shown in figure (2).

Then he measured the mass of the packed volume 50 cm^3 sample of green gram and it was found to be 3.8×10^{-2} kg.

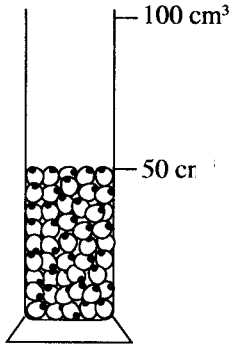


Figure (2)

Subsequently he introduced the green gram sample into a measuring cylinder containing 50 cm^3 of water and found that the water level raised to 82 cm^3 mark. See figure (3).

(i) What is the material volume of green gram?

Material volume of green gram = 32 cm^3 = 3.2×10^{-5} m^3

..... **(01)**

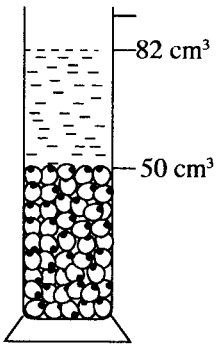


Figure (3)

(ii) Calculate the packing fraction (f_p) of green gram.

Packing fraction of green gram $f_p = \frac{32}{50}$

or = 0.64 ..... **(01)**

(iii) Calculate the bulk density (d_B) of green gram in kg m^{-3}.

Bulk density of green gram $d_B = \frac{3.8 \times 10^{-2}}{50 \times 10^{-6}}$ kg m^{-3}

$= 7.6 \times 10^2$ kg m^{-3} ..... **(01)**

(iv) Calculate the density (d_M) of material of green gram in kg m^{-3}.

Material density of green gram $d_M = \frac{38 \times 10^{-3}}{3.2 \times 10^{-5}}$ kg m^{-3}

$= 1.187 \times 10^3$ kg m^{-3}

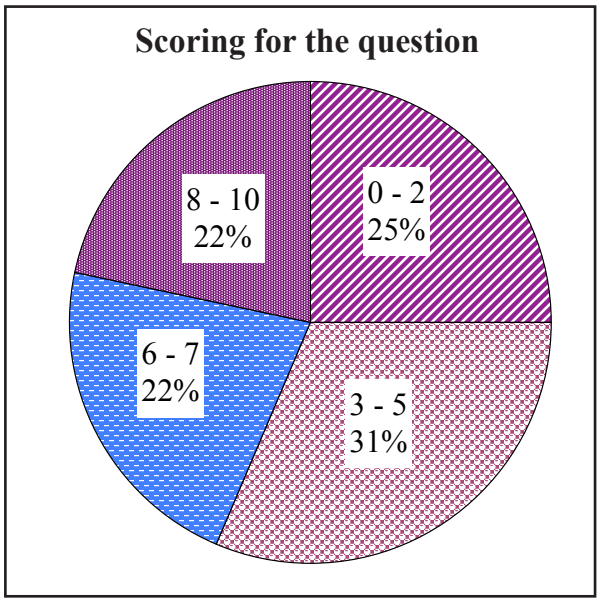
$(1.18 \times 10^3 - 1.19 \times 10^3)$ ..... **(01)**

(*g*) A polythene bag is to be designed to pack 1 kg of green gram. Calculate the minimum volume of the bag needed.

Minimum Volume of the bag $\frac{1}{d_B}$ OR $\frac{50}{38} \times 1000$ cm^3 = 1315 cm^3 = 1.315×10^{-3} m^3

$(1.31 \times 10^{-3}$ m$^3 - 1.32 \times 10^{-3}$ m$^3)$ ..... **(01)**

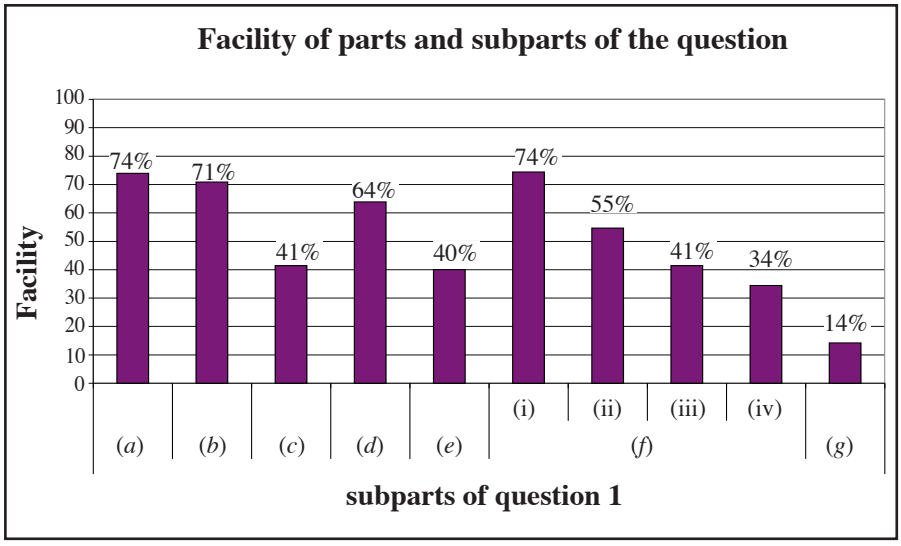
Summary of observations, conclusions and suggestions about answering question number 1 :



Though the question is compulsory, it has been answered by 98% of candidates. This question carries 10 marks.
The distribution of scores is as follows.

Mark 0-2 class interval 25%,
Mark 3-5 class interval 31%,
Mark 6-7 class interval 22%,
Mark 8-10 class interval 22%.

The percentage of candidates who have obtained 8 or more than 8 marks is 22% and percentage of candidates who have obtained 2 or less than 2 marks is 25%.



This question has 10 subparts and facility indices of 5 subparts are higher than 50%. The subparts with lower facilities are (*g*) and it is 14%. The subparts with a higher facility are (*a*) and (*f*)(i), it is 74%.

The highest facility of 74% is there for part (*a*) and part (*f*)(i). Simple mathematical knowedge has been tested there. Subpart (*b*) has a 71% of facility because it has been expected an expression for the volume of a sphere. The least facility is associated with the subpart (*g*) and it is 14%. The bulk density of Mung bean has not been substituted. Therefore it had been lead to have a lower achievement level. The facility of 8 subparts out of the 10 parts have exceeded 40%.

2. You are asked to determine the dew point of air in the laboratory experimentally, and determine its relative humidity.

(*a*) Write down an expression for the relative humidity (RH) in terms of saturated vapour pressures.

$$RH = \frac{\text{Saturated (water) vapour pressure at dew point}}{\text{Saturated (water) vapour pressure at room temperature}} \times 100$$ ..... **(01)**

(*b*) In addition to a polished calorimeter with a lid and a stirrer, what other items would you require to carry out this experiment?

Thermomrter (0 – 50 C°), Water, (beaker of) ice pieces,

[Glass plate, two stands, piece of blotting paper]

(All three underlined items correct) ..... **(01)**

(*c*) Write down **two** factors that need to pay attention **before starting** the experiment in order to obtain a final result with better accuracy, and state experimental precautions that you would take to minimize them.

	Factors	**Experimental Precautions**
(1)	Exhale air altering the moisture level around the calorimeter	Keeping a **glass plate to block the exhaled air** OR wearing a mask .....**(01)**
(2)	Fans, winds, air conditioners disturbing the dew formation on the surface of the calorimeter	Switch off fans, close windows and air conditioners ..... **(01)**

(*d*) Small pieces of ice are used for this experiment. Give reasons for this.

Lowering or raising of the temperature of water can be done slowly or in a controlled manner, **OR** Formation or dissappearance of dew can be observed well, **OR** Dew point can be measured accurately **OR** Dew point can be noted accurately, **OR** Temperature at which dew appears can be recorded accurately ..... **(01)**

(*e*) What practical difficulties would you face if several pieces of ice are added to water at a time?

It is not possible to observe the disappearance of dew as a thin layer of water is formed on the surface of the calorimeter ..... **(01)**

(*f*) Exactly at what instants do you take the readings in this experiment?

At the instants when dew just begins to apper and disapper, **OR** when the shine begins to disappear and appear. ..... **(01)**

(*g*) What is the reason for using the calorimeter with a lid in this experiment?

It will prevent spilling of cold and saturated air present inside the calorimeter and interfering with the dew formation. ..... **(01)**

(*h*) What is the other reading that you should take in this experiment?

Room temperature ..... **(01)**

(*i*) When the temperature of a certain laboratory was 28 °C, its dew point was found to be 24 °C. Using the following table, determine the relative humidity of the laboratory.

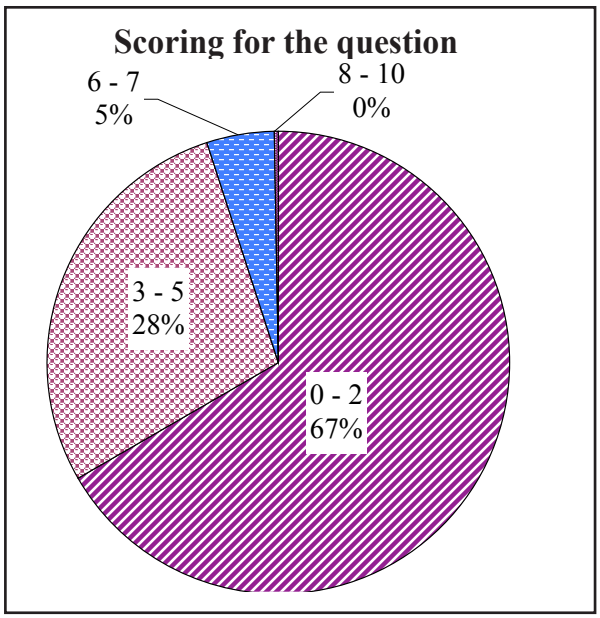
Temperature (°C)	20	22	24	26	28	30	32
Saturated water vapour pressure (mmHg)	17.53	19.83	22.38	25.20	28.35	31.82	35.66

Relative humidity $= \frac{22.38}{28.35} \times 100$

$= 79\%$

(78.9% – 79%) ..... **(01)**

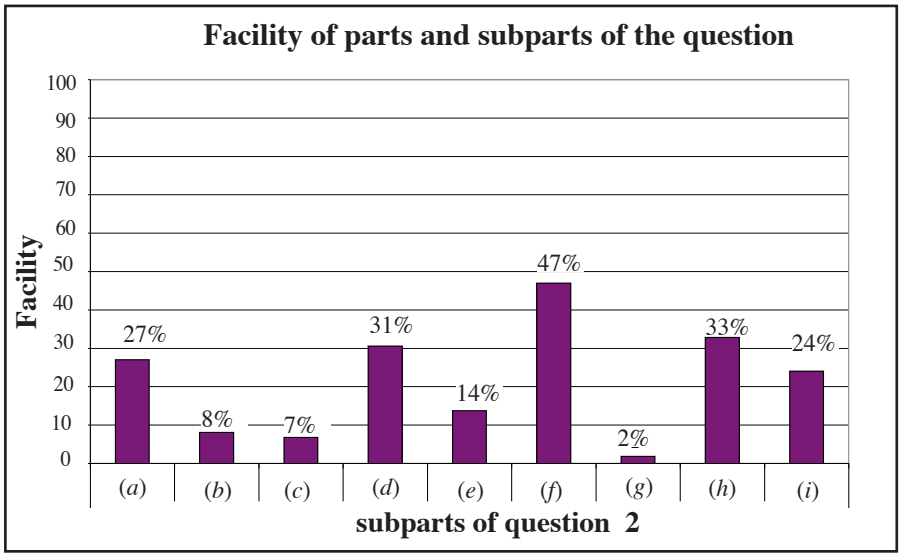
Summary of observations, conclusions and suggestions about answering question Number 2 :



Through the question number 2 is also compulsory only 99% of the candidates had answered it. This question carries 10 marks. The marks distribution was as follows.

Mark 0-2 class interval 67%
Mark 3-5 class interval 28%
Mark 6-7 class interval 5%
Mark 8-10 class interval 0%

0% of the candidates have obtained 8 or more than 8 marks but 67% of thr candidates have scored 2 or less than 2 marks.

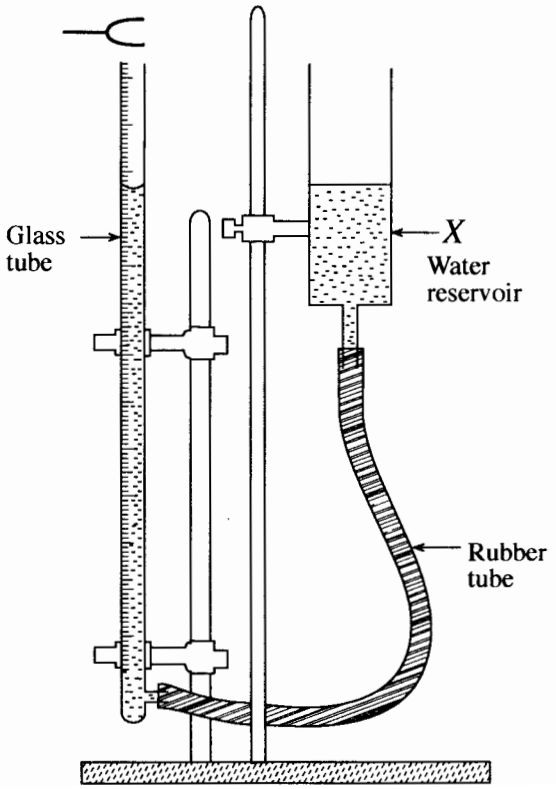


There are 9 subparts in this question and the subpart with the lowest facility is (*g*) and it is 2%. The subpart with the highest facility is (*f*) and it is 47%.

Subpart (*f*) has the highest facility among all the parts of the question number 2 and it is 47%. The way of observing a practical experiment has been considered there. Subpart (*b*), (*c*) and (*g*) have a facility which is less than 10%. Inability to name all three items that are used for the experiment has reduced the facility less than 8%. Poor attention regarding experiment precautions has lead a lower. facility as low as 7% for the subpart (*c*). A facility of 2% is there for the (*g*) due to a poor achievement level regarding, applying suitable techniques to overcome the practical difficulties and they by to improve the accuracy of experiments when doing the practical experiments.

The proficiency can be improved by doing the practical experiments with a keen interest and by answering structured essay questions parallely. The facility of part (i) is as low as 24%. It is due to a lower achievement level regarding defining and calculation of the substituted values in an expression, which is obtained by analysing a table. And those who have good understanding are lack in the ability to substitute the values and to obtain the answer by calculating. The achievement level could be improved by giving the attention to develop the skills regarding defining the correct expressions and substituting the values in them. Facility of (*a*) is as low as 27%. because it seems like the candidates did not possess the ability to understand the concepts interms of the definitions. If so happen the facility would be more than this.

3. Figure shows an alternative apparatus to find the speed of sound in air using a resonance tube with one end closed. The principle of this apparatus is similar to the principle of the apparatus normally used in the school laboratory. The resonance tube in this apparatus is a glass tube with a calibrated scale. The water level in the resonance tube is raised and lowered by raising and lowering of a water reservoir *X* which is connected to the resonance tube with a flexible rubber tube.

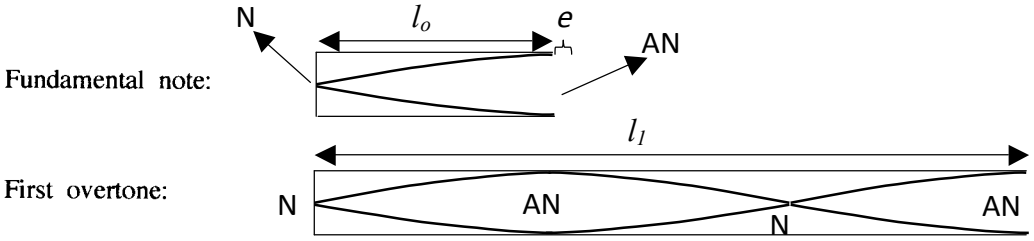


(*a*) What type of wave is formed inside the tube at resonance?

Standing wave **OR** Stationary wave ..... **(01)**

(*b*) You are given a tuning fork of known frequency *f* and asked to obtain the resonant lengths l_0 and l_1 corresponding to the fundamental note and the first overtone respectively.

(i) Draw the wave patterns for the two modes of vibrations, and mark the lengths l_0, l_1, end correction *e*, Nodes (N) and Anti-nodes (AN).
(You are expected to draw the tube for the first overtone).



To draw both wave patterns (look for the length of overtone approximately three times) ..... **(01)**

If all the labelling are correct (at least in one diagram)
(Instead of AN, A can also be accepted) ..... **(01)**

(ii) (1) If λ is the wavelength corresponding to the fundamental note, write down an expression for λ in terms of, l_0 and e.

$$\lambda = 4(l_0 + e)$$ ..... **(01)**

(2) Write down a similar expression for the wave length corresponding to the first overtone

$$\lambda = \frac{4}{3}(l_1 + e)$$ ..... **(01)**

(3) If v is the speed of sound in air, derive an expression for v in terms of the known and measured quantities.

$$l_1 - l_0 = \frac{\lambda}{2}, \quad \Rightarrow \quad v = f\lambda$$

$$v = 2f(l_1 - l_0)$$ ..... **(01)**

(*c*) Before taking the measurement for l_0, the water level in the resonance tube has to be raised upto the top. Explain the reason for this.

To detect the fundamental note without missing it. **OR** to get the fundamental note first.

(*d*) Write down **two** major differences in the experimental procedure when using the apparatus given in the question compared to the method adapted when using apparatus generally available in school laboratory.

(1) Tube is fixed (or water level movable) ..... **(01)**

(2) Measuring scale is fixed (or calibrated tube) **OR** does not need a metre ruler.
(Both correct) ..... **(01)**

(*e*) At room temperature (28 °C), when a 512 Hz tuning fork is used, the corresponding lengths of the resonance for fundamental note and the first overtone are found to be 15.5 cm and 50.5 cm respectively.

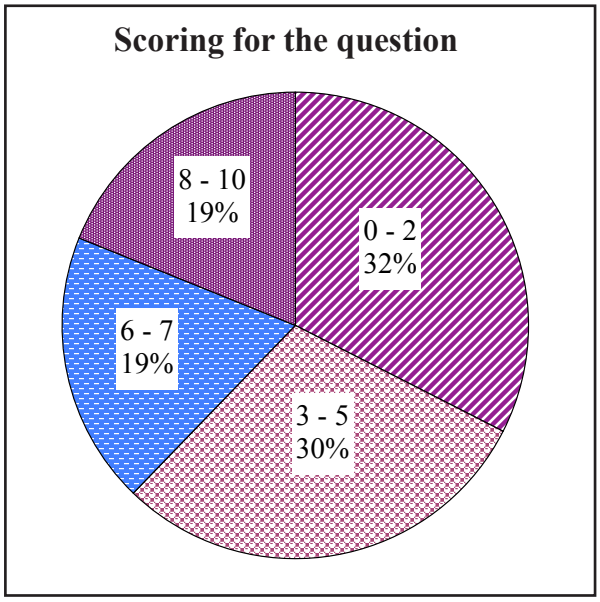
Calculate the speed of sound in air at room temperature.

$$v = 2 \times 512(50.5 - 15.5) \times 10^{-2} \text{ m s}^{-1} \quad \Rightarrow \quad v = 358.4 \text{ m s}^{-1}$$

Correct substitution ..... **(01)**

Final answer ..... **(01)**

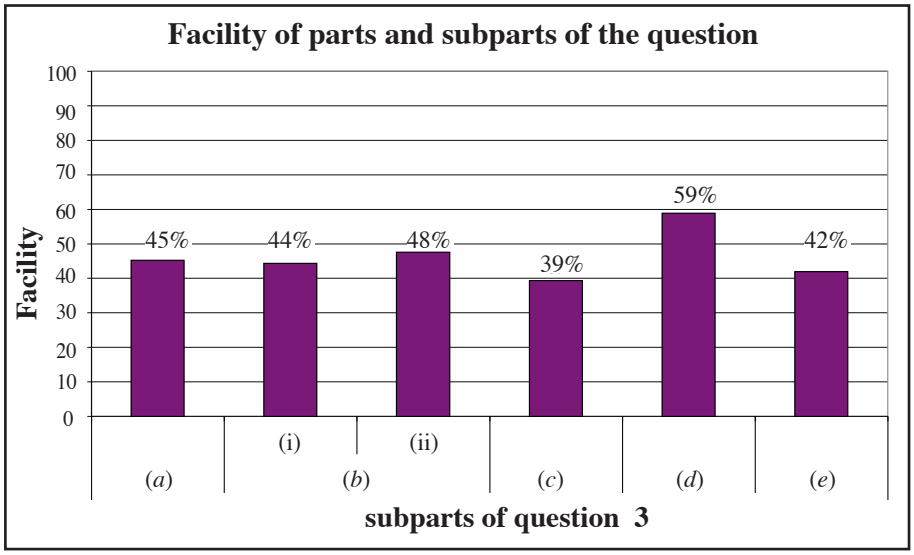
Summary of observations, conclusions and suggestions about answering question 3 :



This question is also one of the compulsory question. But only 99% of the students have answered. This question carries 10 marks.
The marks distribution was as follows.

Mark 0-2 class interval 32%
Mark 3-5 class interval 30%
Mark 5-7 class interval 19%
Mark 8-10 class interval 19%

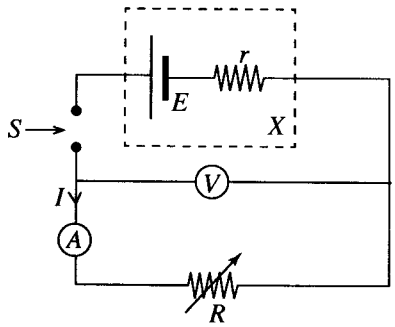
19% of the candidates has obtained 8 or more than 8 marks. But 32% of the candidates have obtained 2 or less than 2 marks.



6 subparts are there in this question and 5 subparts out of them shows more than 40% of a facility. The subparts with the least facilitiy is (*c*) and facility of it is 39%. The subpart with the highest facility is (*d*) and it is 59%.

19% of the candidates have obtained 8 -10 marks for this question. The question is based on an altered equipment which can be used to determine speed of sound in air in the laboratory, instead of using a closed resenant tube. The highest facility has been acuired by subpart (*d*) and it is 59%. Facilities of all the other subparts lie below 48%. Facility of subpart (*b*)(i) is 44%. It shows that the students should be trained well to draw the shapes of stationary waves inside the tubes. Facility of subpart (*b*)(ii) is 48%. It implies that the students need more training to derive the relevant expressions using the theories while they are engaging in the laboratory practicals. Then the applications of the theories can be proved. Futher the proficiency of the students can be improved by answering the structured essay questions of the past examinations.

4. The given circuit can be used in a school laboratory to experimentally determine the e.m.f. (E), and the internal resistance (r) of a dry cell X using a graphical method.



The experimental procedure consists of measuring the potential difference V across the terminals of the cell for different values of I using a voltmeter with very high internal resistance.

(a) Write down an expression for V in terms of I, E, and r.

$V = E - Ir$ ..... **(01)**

(b) (i) Name the variable resistor that is available in the school laboratory, which could be used for this experiment.

Rheostat

(No marks for resistance box) ..... **(01)**

(ii) The key S should be used properly to obtain expected results from this experiment.

(1) What is the type of key that is most suitable to be used as S?

Tap key **OR** drawing a diagram to show a tap key ..... **(01)**

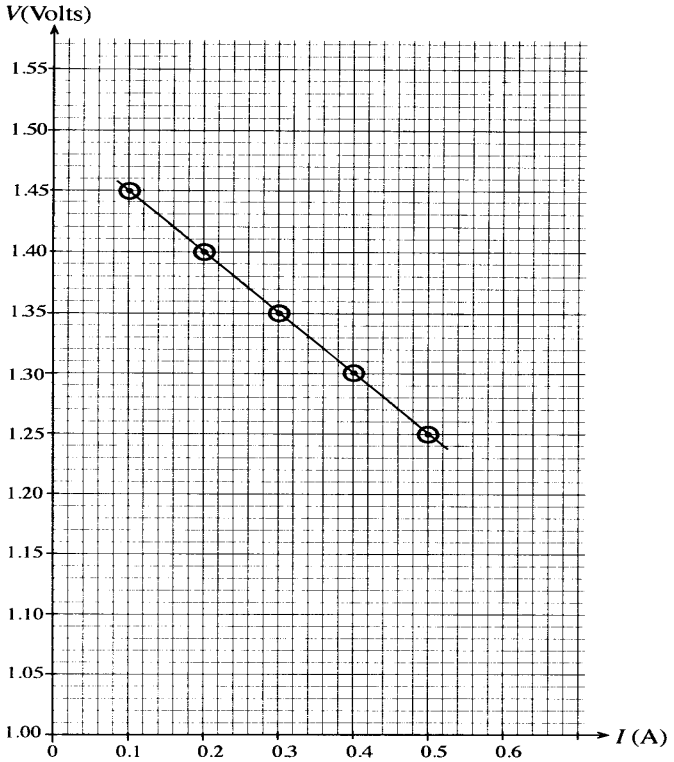
(2) What is the experimental procedure you adapt when operating the key?

Vary R while keeping S open and **close the key momentarily** when observing or taking the I and V readings. ..... **(01)**

(iii) How do you confirm experimentally that the cell has not run down while carrying out the experiment?

After taking the final reading go back to the first reading and check its value again to see if it is different. ..... **(01)**

(c) A graph of V against I plotted using a set of data obtained from such an experiment is shown below.



(i) Use the graph to find the following.

(1) Internal resistance, r of the cell.

Gradient of the graph $= \dfrac{1.24 - 1.44}{0.52 - 0.12}$

$= (-)\ 0.5\ \Omega$ ..... **(01)**

(Select two points which are far apart)

(2) E.m.f. E of the cell.

Intercept $= E = 1.5$ V ..... **(01)**

When giving the mark look for the extension in the graph to determine the intercepts **OR** using one point from the graph and substituting it into the equation and finding E.

(ii) Use the values obtained under (*c*)(i) and the expression obtained under (*a*) to deduce the current (I_{SC}) through the cell if it is short circuited.

Using $V = E - IR$ and taking V as zero when the cell is short circuited

$E = I_{SC}\, r$ **OR**

$I_{SC} = \dfrac{1.5}{0.5}$ ..... **(01)**

$= 3.0\ A$

(*d*) A supply voltage in the range, 8.6 V – 9.0 V will have to be applied to operate a certain electronic item properly. The resistance across the supply voltage terminals of the electronic item is 30 Ω. Suppose you have a choice of selecting a single dry cell battery having E = 9 V and r = 10 Ω **or** a combination of six dry cell batteries each having E = 1.5 V and r = 0.2 Ω and connected in series, for the operation of the above electronic item. Using the data given in this part, explain how you would select a proper battery.

When the dry cell battery having $E =$ 9V and $r =$ 10 Ω is connected, the terminal voltage (V) across the electronic device is given by $V = \left(\dfrac{9}{30 + 10}\right) \times 30 = 6.75$ V

When six 1.5 V dry cell batteries having E = 9V and $r = 0.2 \times 6\Omega$ are connected, the terminal voltage (V) across the electronic device is given by $V = \dfrac{9}{3.0 + 1.2} \times 30$

= 8.65 V, Therefore, only six 1.5V dry cell batteries can provide a voltage greater than 8.5 V.

Correct substitution for any of the voltage calculation ..... **(01)**

If both calculated voltage values are correct and correct argument ..... **(01)**

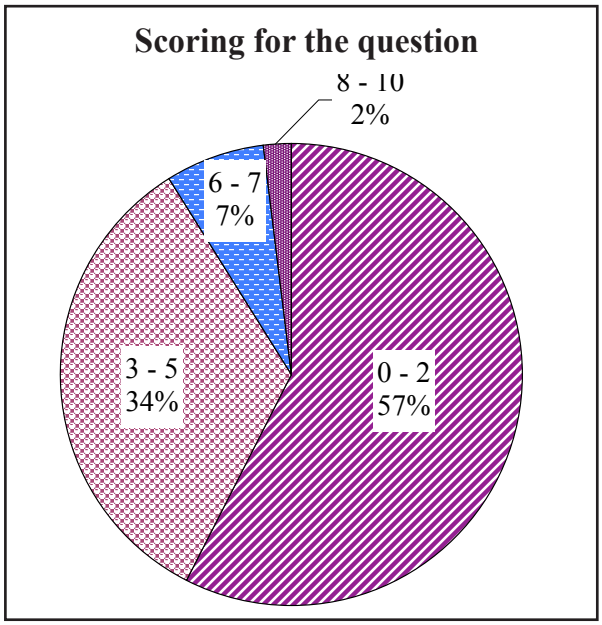
Alternative method :

Instead of calculating the potential differences across the device one can argue in terms of current

Conversion of voltage range (8.6 V – 9.0 V) to corresponding current range (0.287 A – 0.30 A) ..... **(01)**

Calculation of current from each dry cell and for correct argument ..... **(01)**

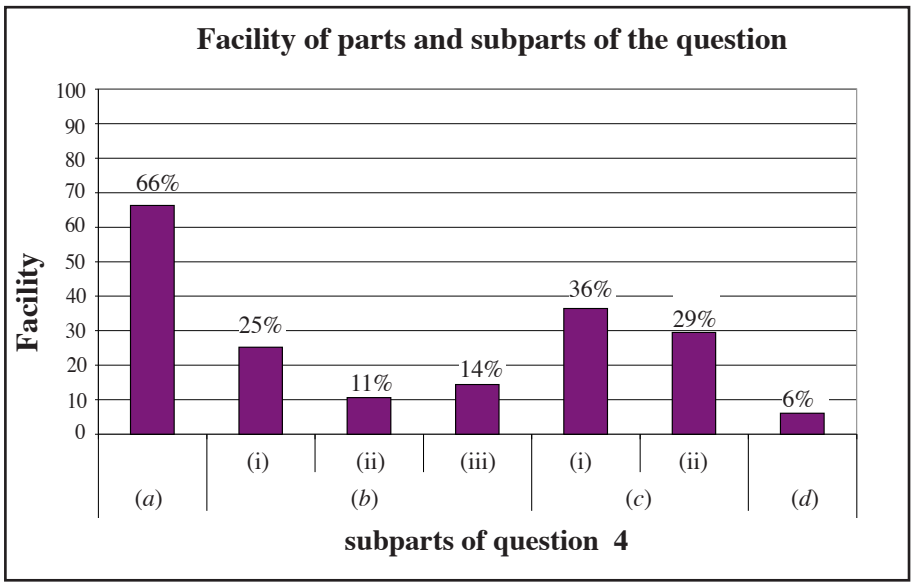
Summary of observations, conclusions and suggestions about answering question 4 :



Question number 4 is also a compulsory question. But only 98% of the students have answered it. This question carries 10 marks.
The marks distribution was as follows.

Mark 0-2 class interval 57%
Mark 3-5 class interval 34%
Mark 6-7 class interval 7%
Mark 8-10 class interval 2%

Only 2% of the candidates have obtained 8 or more than 8 marks and 57% have obtained 2 or less than 2 marks.



There are 7 subparts in this question and 2 parts out of them have a facility more than 36%.Subparts

(*d*) has the lowest facility and it is 6%. The subpart with highest facility is (*a*) and it is 66%.

The facility of subpart (*a*) is the highest due to a good level of achievement of the candidates regarding deriving an expression for the potential differce across the terminals of a dry cell when a current is flowing achievement level of part (*b*)(ii) and (*b*)(iii) were 11% and 14% respectively. It may due to a lower level of achievement of the students regarding the selection of suitable switches. It is very important to improve the knowledge to select suitable electrical items when constructing a circuit. The students must be trained regarding basic electrical devices, constructing and activation of the circuits and taking the readings. Lack of knowledge regarding the application of Kirchhoff's Lows and potential divider have reduced the achievement level of students up to 6%. Achievement level can be improved by doing the exercises relevant to electrical circuits.

Part B - Essay

5. A particle of mass m_1 is fixed to the rim of a horizontal ring of radius r and negligible mass as shown in figure (1). POQ is a vertical axis passing through the centre O of the ring.

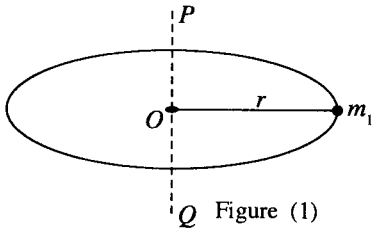


Figure (1)

(*a*) (i) Write down an expression for the moment of inertia I_1 of the particle about the vertical axis POQ in terms of m_1 and r.

(ii) Another particle of mass m_2 is now fixed to the rim of the ring which is diametrically opposite to m_1, and the system is rotated about the axis POQ with a constant angular speed ω. If I_2 is the moment of inertia of mass m_2 about the axis POQ, write down an expression for the total rotational kinetic energy (E) of the system.

(iii) If I_0 represents the total moment of inertia of the above system in (*a*) (ii) about the axis POQ, using the expression obtained in (*a*)(ii) show that $I_0 = I_1 + I_2$.

(*b*) Instead of m_1 and m_2, 10 identical particles, each of mass m, are now fixed to the rim of the ring with equal spacing. If I is the moment of inertia of a particle about the vertical axis POQ, write down an expression for total moment of inertia (I_T) of the system about the vertical axis POQ.

(*c*) Now, the ring described in (*b*) above is fixed onto an axle of negligible moment of inertia and coinciding with the vertical axis POQ using symmetrically fixed spokes of negligible mass as shown in the figure (2). The system is then started rotating from rest at time $t = 0$ in a horizontal plane about the axis POQ with a constant angular acceleration α and reached a constant angular speed ω.

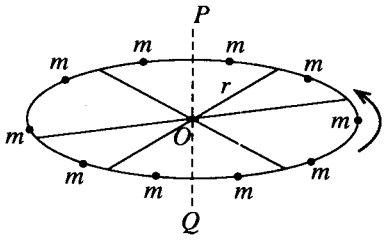


Figure (2)

(i) (1) Obtain an expression for the time t taken by the system to reach the constant angular speed ω.

(2) How many revolutions have been made by the system when it reaches the constant angular speed ω?

(ii) Write down an expression for the centripetal force (F) acting on one particle when it is rotating about the axis POQ with a constant angular speed ω.

(*d*) The structure of the merry-go-round shown in figure (3) which is at rest is similar to the structure of the system described in (c) above. However, instead of fixed masses m, the system has 10 chairs occupied by riders and hung by chains of negligible mass. The moment of inertia of the merry-go-round, **without riders and chairs**, about the axis POQ is 32 000 kg m^2.

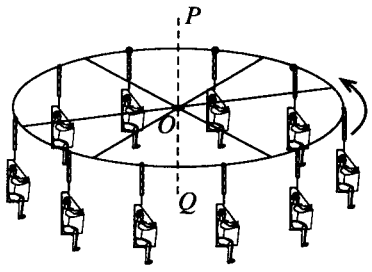


Figure (3)

Consider a situation where the merry-go-round is rotating about the axis POQ with a constant angular speed of 12 revolutions per minute with all the chairs being occupied by riders. When the merry-go-round rotates, all the chains are inclined to the vertical by an angle θ, and figure (4) shows the situation with respect to one rider.

Use $\pi = 3$ for relevant calculations.

(i) If the riders are of mass 70 kg each and the chairs are of 20 kg each, calculate the total moment of inertia of the system about the axis POQ. When calculating the moment of inertia assume that the total mass of the rider and his chair **is concentrated** at a horizontal distance of 10 m from the axis POQ.

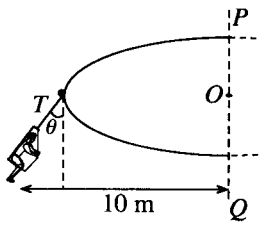


Figure (4)

(ii) Calculate the value of θ.

(iii) What is the total rotational kinetic energy of the system?

(*a*) (i) Moment of inertia of the particle about the vertical axis *POQ*,

$I_1 = m_1 r^2$ ..... **(01)**

(ii) Total rotational kinetic energy of the system,

$E = \frac{1}{2} I_1 \omega^2 + \frac{1}{2} I_2 \omega^2$ **OR**

$E = \frac{1}{2} m_1 r^2 \omega^2 + \frac{1}{2} m_2 r^2 \omega^2$ ..... **(01)**

(iii) $\frac{1}{2} I_0 \omega^2 = \frac{1}{2} I_1 \omega^2 + \frac{1}{2} I_2 \omega^2$ ..... **(01)**

$\therefore I_0 = I_1 + I_2$

(*b*) (i) Total moment of inertia of the system about the vertical axis *POQ*.

$I_T = I_1 + I_2 + ... + I_{10}$

$= mr^2 + mr^2 + ...$

$= 10\, mr^2 = 10I$ ..... **(01)**

(*c*) (i) (1) For a system rotating with constant angular acceleration α, the relation between initial and final angular speeds is

$\omega_0 = \omega_0 + \alpha t$

$\omega = 0 + \alpha t$

$\therefore \omega = 0 + \alpha t$

$\therefore t = \frac{\omega}{\alpha}$ ..... **(01)**

(2) Total angle θ through which the system rotated is given by,

$\omega^2 = \omega_0^2 + 2\alpha\theta$ **OR** $\theta = \omega_0 t + \frac{1}{2}\alpha\alpha t^2$ ..... **(01)**

$\theta = \frac{\omega^2}{2\alpha}$

Number of revolutions made by the system when it reaches angular speed $\omega = \frac{\theta}{2\pi}$

$= \frac{\omega^2}{4\pi\alpha}$ ..... **(01)**

(ii) Centripetal force acting on one particle $F = m\omega^2 r$ ..... **(01)**

(*d*) (i) The moment of inertia of the system about the axis *POQ*

$= 32{,}000 + (70 + 20) \times 10^2 \times 10$ **(01)**

$= 122{,}000 \text{ kg m}^2$ **(01)**

(ii) Take the mass of a chair with the passenger as m, then,

$T \cos \theta = mg$ ..... **(01)**

$T \sin \theta = ma$
$= m\omega^2 r$ } (Either of the above equation) ..... **(01)**

$\therefore \tan \theta = \frac{\omega^2 r}{g}$

$= \left(\frac{12 \times 2\pi}{60} \right)^2 \times \frac{10}{10}$ (Correct substitution) ..... **(01)**

$= 1.44$

$\theta = 55°$ $(55° - 13')$ ..... **(01)**

(if $\pi = 3.14$ then $\tan \theta = 1.58$ and $\theta = 57°$ $(57° - 57° 40')$)

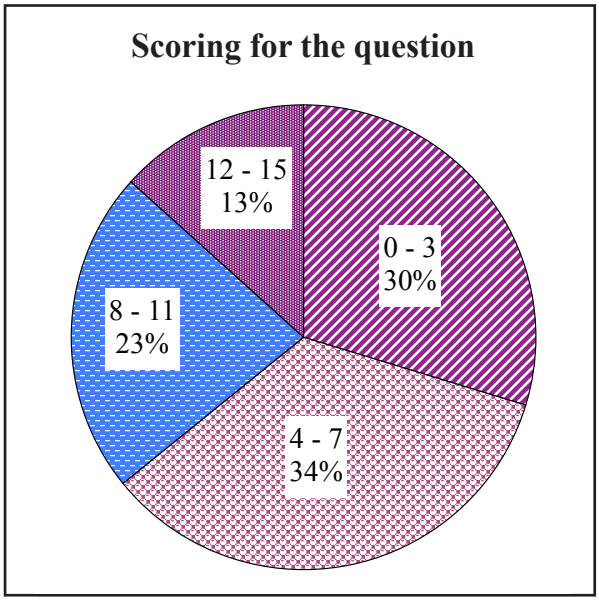
(iii) Total rotational kinetic energy of the system $= \frac{1}{2} I\omega^2$

$= \frac{1}{2} \times 122{,}000 \times 1.44$

$=$ 87840 J (87840 J – 87850 J)..... **(01)**

(if $\pi = 3.14$ then 96220 J (96220 J – 96230 J))

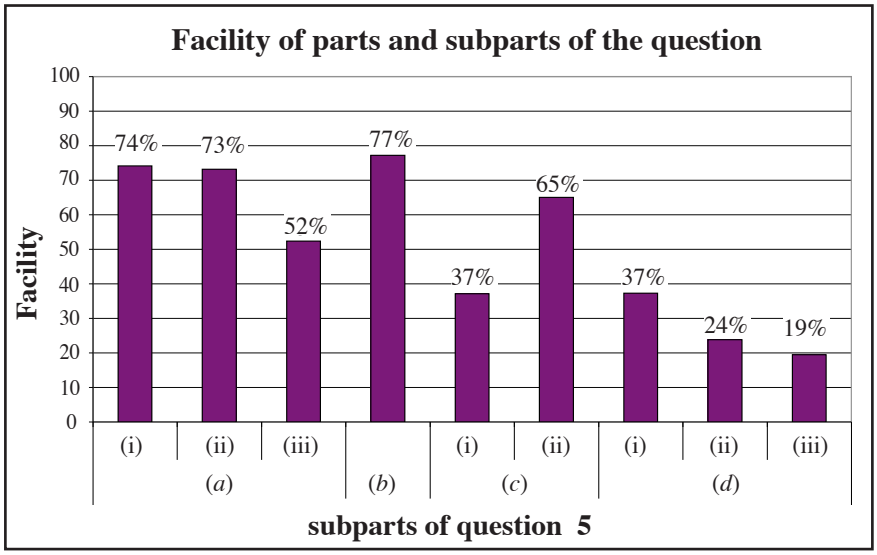
Summary of observations, conclusions and suggestions about answering question 5 :



Although this is not compulsory question. 57% of the students had answered. This question carries 15 marks. The distribution of marks obtained is as follows.

Mark 0-3 class interval 30%
Mark 4-7 class interval 34%
Mark 8-11 class interval 23%
Mark 12-15 class interval 13%

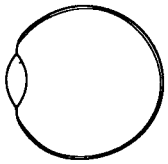
13% of the candidates have scored 12 or more than 12 marks, but 30% have obtained 3 marks or less than 3 marks.



There are 9 subparts in this question. And 5 subparts out of 9 have a facility more than 52%. The subpart with least facility 19% is (*d*)(iii). The subpart with the highest facility 77% is (*b*).

This question is based on rotational motion of the unit Mechanics.The concepts regarding Rotational Kinetic energy, moment of inertia, centripetal force and centripetal acceleation have been evaluated in this question. Equations of angular motion have also been combined here. 57% of the candidates had selected the question. There are 9 subparts and part (*b*) has the highest facility which is 77%. It is because number of students who have gathered the knowledge regarding, finding the moment of inertia of a mass distribution, is higher. It shows a facility which is more than 50% for parts (*a*)(iii) and (*b*). The facility of parts (*d*)(ii) and (*d*)(iii) is less than 25%. In sufficient skills regarding resolution of forces in circular motion and obtaning the magnitudes of angles using tables trigonometric ratios, are the causes.

6. The effective focal length of the cornea and the eye-lens can be considered as the focal length of an eye. The muscles controlling the curvature of the lens permit the eye to focus on the retina light from objects at different distances from the eye. The figure shows a simplified diagram of the eye with an eye-lens of effective focal length. When the eye muscles are relaxed the focal length of a healthy eye of a child is about 2.5 cm. The near point of his eye is at a distance of 25 cm.



(Copy the diagram given in the figure and use it when drawing ray diagrams.)

(*a*) Draw a ray diagram for the situation where light from a far away object is focused onto the retina of the eye of the child with healthy eye when his eye muscles are relaxed. What is the distance between the eye-lens and the retina?

(*b*) Draw a ray diagram for a situation where a point source of light is placed at the near point, is clearly seen by the child with healthy eye. Calculate the focal length of the eye at this instant.

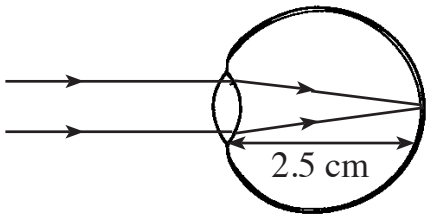
(*c*) Another child has the focal length equal to that of the healthy child when the eye muscles are relaxed and also has the focal length calculated for the situation in (*b*). However, the position of his retina is located 0.2 cm behind the position of the retina of the healthy child.

(i) Using the image produced by a point source of light as mentioned in (b) above, indicate his near point and far point by drawing two separate ray diagrams. Calculate the distances from the eye-lens to the near point and to the far point of this child.

(ii) Sketch a ray diagram illustrating as to how the required correction can be done using a suitable lens. Calculate the focal length of the corrective lens needed.

(*d*) When a person becomes older the ability to change the focal length of eyes gets weaker and the distance to the near point of the eye increases. If the child mentioned in part (*c*) above would face such a situation, what is the type of additional corrective lens that the child should wear (convergent/divergent)? Give reasons for your answer.

(*a*)

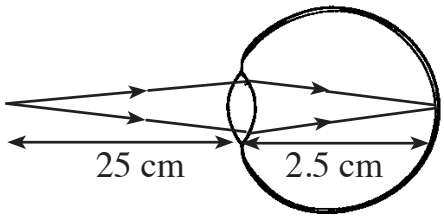


Drawing the correct ray diagram ..... **(01)**

(Look for **two parallel lines with arrows** to the point image at the retina)

(The distance between the eye lens and the retina = 2.5 cm ..... **(01)**

(*b*)



Drawing the correct ray diagram ..... **(01)**

(Look for **two lines with arrows** from a point source to the point image at the retina)

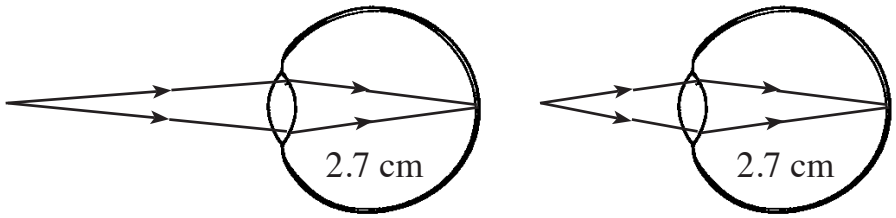
Let *f* be the focal length, then

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ (u = 25 cm ; v = –2.5 cm)

$\frac{1}{-2.5} - \frac{1}{25} = \frac{1}{f}$ (Correct substitution) ..... **(01)**

f = – 2.273 cm OR 2.273 cm ..... **(01)**
(2.27 cm – 2.30 cm)

(*c*) (i)



(a) Far point (b) Near point

Drawing the correct ray diagram for an object at the **far point** ..... **(01)**

(Look for two lines with arrows from a point source to the point image at the retina)

Drawing the correct ray diagram for an object at the **near point** ..... **(01)**

(Look for two lines with arrows from a point source to the point image at the retina)

Calculation of the distance to the far point : f = – 2.5 cm, v = – 2.7 cm, u = ?

$-\frac{1}{2.7} - \frac{1}{u} = -\frac{1}{2.5}$ (Correct substitution) ..... **(01)**

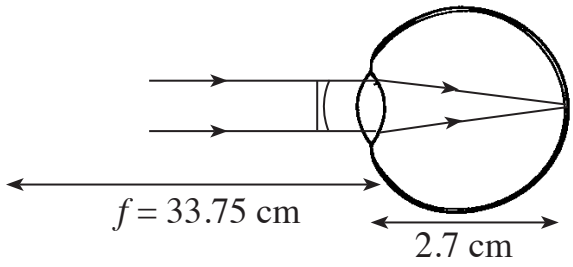
u = 33.75 cm ..... **(01)**

Calculation of the distance to near point : f = – 2.273 cm, v = – 2.7 cm, u = ?

$-\frac{1}{2.7} - \frac{1}{u} = -\frac{1}{2.273}$ (Correct substitution) ..... **(01)**

u = 14.373 cm (14.25 cm – 14.40 cm). ..... **(01)**

(ii) Ray diagram for the required correction with a corrective lens



Choosing a divergent lens ..... **(01)**
Correct ray diagram with diverging lens ..... **(01)**
(Look for two dotted lines from the point source and parallel lines with arrows to the point image at the retina)

$f = 33.75$ cm ..... **(01)**

OR

Focal length of the corrective lens ; $u = -2.5$ cm, $v = -2.7$ cm, $f = ?$

$\frac{1}{-2.7} - \frac{1}{-2.5} = \frac{1}{f}$ **OR** $\frac{1}{33.75} - \frac{1}{\infty} = \frac{1}{f}$ ..... **(01)**

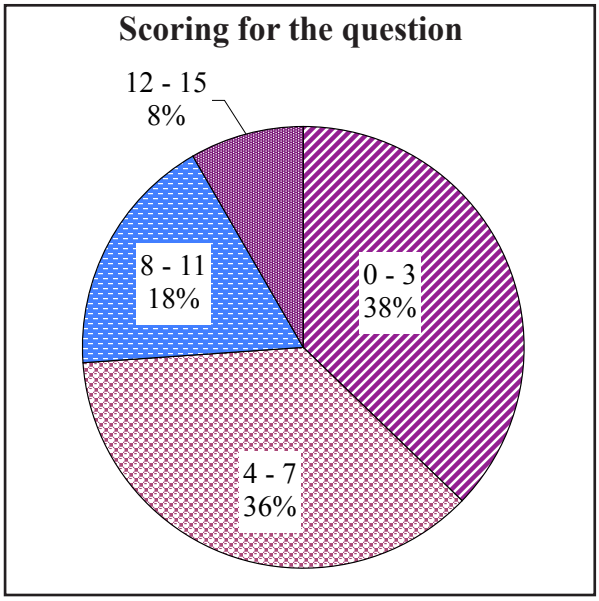
$f = 33.75$ cm

(*d*) Additional corrective lens should be a converging lens

Reason :

The image formed by the eye lens should be moved forward to coincide with the retina **OR**
When the eye lens gets weaker the image of an object at the normal near point will be formed behind the retina. Therefore, light passing through the lens has to be converged to the retina.
..... **(01)**

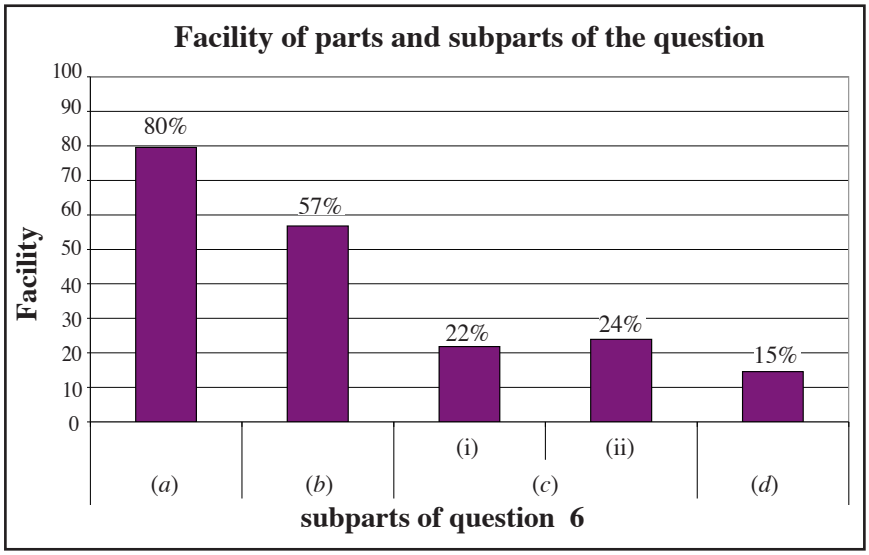
Summary of observations, conclusions and suggestions about answering question 6 :



A higher percentage as 70% of selection has been there for this question. This question carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 38%
Mark 4-7 class interval 36%
Mark 8-11 class interval 18%
Mark 12-15 class interval 8%

8% of the candidates has obtained 12 or more than 12 marks. but 38% of the candidates has obtained 3 marks or less than 3 marks.



There are 5 subparts in this question and facility of 2 subparts out of them has 57% or more than that. The subparts with the least facility is (*d*) and it is 15%. The subpart with the highest facility is (*a*) and it is 80%.

This question has been prepared under sub unit optics of the unit Osullation and Waves. It is based on function of the eye and it has been assessed the knowledge of eye defects and remedies for them. 70% of the candidates have selected this question. There are 5 subpart and the highest facility 80% is there for part (*a*).

Achievement level of students regarding the funtion of eye when looking at distant point was at a distant point. Part (*d*) had the lowest facility 15% and it is due to the inability to identify the correct remedial lense for the eye defect. It is concluded that thre is a lower achivement level regarding identification of the eye defect and drawing the relevant ray diagram. Because the facilities of subparts (*c*)(i) and (*c*)(ii) are 22% and 24% respectively. Therefore it is recommended to improve the achievement level of the students by improving the knowledge on eye defect and the remedies.

7. Write down Poiseuille's equation for the rate of flow, Q, of a liquid through a horizontal cylindrical narrow tube under a pressure difference of ΔP. Identify all the other symbols you used.

Under the above condition, the resistance exerted by the tube against the rate of flow of the liquid, Q, can be defined as the flow resistance $R = \frac{\Delta P}{Q}$.

(*a*) What physical quantities associated with the tube and the liquid determine the flow resistance R?

(*b*) When a liquid flows under pressure differences of ΔP_1, ΔP_2 and ΔP_3, through three horizontal narrow tubes connected in series as shown in figure (1), the flow resistances exerted by the tubes are R_1, R_2 and R_3 respectively. Using the definition given above for R show that the flow resistance, R_0, of the system can be written as $R_0 = R_1 + R_2 + R_3$. (Neglect edge effects.)

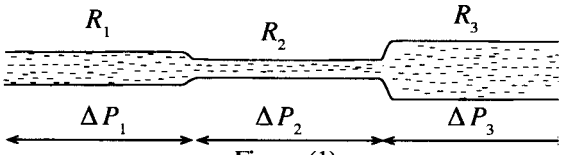


Figure (1)

(*c*) When a liquid flows through two horizontal narrow tubes connected in parallel under a common pressure difference ΔP as shown in figure (2), the flow resistances exerted by the tubes are R_1 and R_2. Show that the flow resistance R_0 of the system can be written as $\frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2}$. (Neglect end effects.)

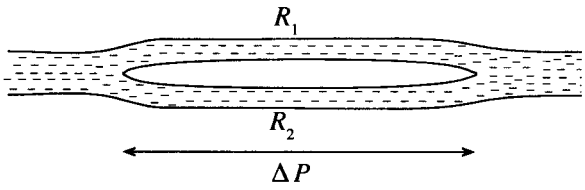


Figure (2)

(*d*) Figure (3) shows a set of horizontal narrow tubes *A*, *B*, *C*, *D* and *E* connected between the point *X* and a common reservoir *Y* so that a liquid can flow from *X* to *Y*. The pressures at *X* and *Y* are maintained at constant values. The flow resistance of each tube is labelled in the diagram in units of mmHg s/cm^3. Tube *B* is divided into two tubes *C* and *D* of equal flow resistances. This simplified model may also be used to illustrate the blood flow through arteries and veins.

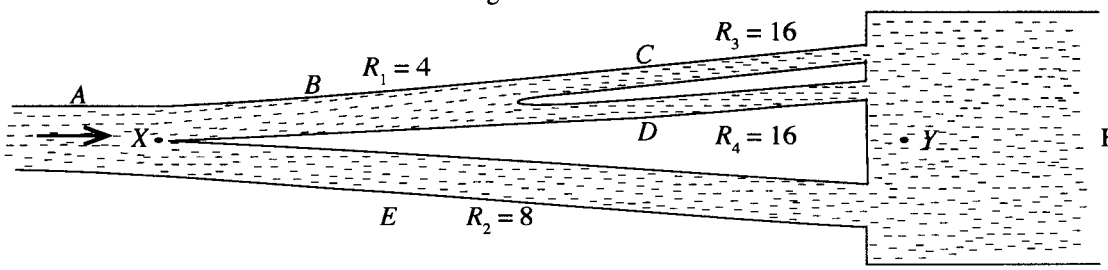


Figure (3)

Give the answers to parts (i), (ii) and (iii) in terms of the given units. (Take $\pi = 3$)

(i) (1) Calculate the flow resistance, due to the system of tubes *B*, *C* and *D* between the points *X* and *Y*.

(2) Calculate the flow resistance, due to the system of tubes, *B*, *C*, *D* and *E* between the points *X* and *Y*.

(ii) If the flow rate of the liquid across *X* is 6 cm^3/s, calculate the pressure difference between *X* and *Y*.

(iii) Using the above results, find the flow rate of the liquid through tube *E*.

(iv) If the length of tube *E* is 2 cm find the internal radius of tube *E*. The viscosity of the liquid is 4.0×10^{-3} Pa s [Take 1 mmHg = 133 Pa]

(*e*) If the temperature of one of the tubes in the system given in part (*d*) is reduced, explain what would happen to the flow rate of the liquid in that tube. Neglect the changes in radius and length of the tube.

Poiseuille's equation : $Q = \frac{\pi \Delta P r^4}{8\eta l}$ ..... **(01)**

η – Viscosity of the liquid l – Length of the tube

r – Radius of the tube

All three correct ..... **(01)**

[Flow resistance against the flow Q, $R = \frac{\Delta P}{Q} = \frac{8\eta l}{\pi r^4}$]

(*a*) Flow resistance is determined by the :

Coefficient of viscosity of the liquid

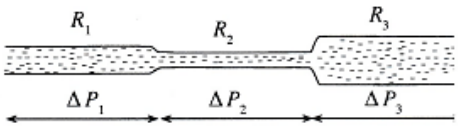
Length of the tube

Radius of the tube.

All three correct ..... **(01)**

(*b*) $\Delta P = \Delta P_1 + \Delta P_2 + \Delta P_3$ ..... (*a*)

$R_0 Q = R_1 Q + R_2 Q + R_3 Q$ ..... (*b*)



OR

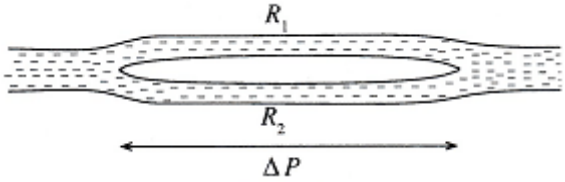
$\left[\frac{\Delta P}{Q} = \frac{\Delta P_1}{Q} + \frac{\Delta P_2}{Q} + \frac{\Delta P_3}{Q} \text{ ..... } (b) \right]$

$R = R_1 + R_2 + R_3$

For equation (a) ..... **(01)**

For equation (b) ..... **(01)**

(*c*) ΔP is common for both tubes



$Q = Q_1 + Q_2$

$\frac{\Delta P}{R_0} = \frac{\Delta P}{R_1} + \frac{\Delta P}{R_2}$ ..... **(01)**

$\frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2}$

(*d*)(i) (1) $R_{CD} = \frac{1}{\frac{1}{16} + \frac{1}{16}}$ **OR** 8 mmHg s/ cm^3 (Correct substitution or answer) ..... **(01)**

$R_{BCD} = 8 + 4$

12 mmHg s/ cm^3 ..... **(01)**

(2) Flow resistance R due to system of tubes B, C, D and E

$R = \frac{1}{\frac{1}{12} + \frac{1}{8}}$ = 4.8 mmHg s/ cm^3 (Correct substitution)..... **(01)**

(ii) Pressure difference between X and Y

$\frac{\Delta P}{Q} = R$ **OR** $\frac{\Delta P}{6} = 4.8$ ..... **(01)**

(iii) Flow rate through E

$$Q = \frac{\Delta P}{R} = \frac{28.8}{8}$$

$= 3.6\ cm^3/s$ ..... **(01)**

(iv) Radius of the tube E

$$Q = \frac{\pi \Delta P r^4}{8\eta l}$$

$3.6 \times 10^{-6} = \frac{3 \times 28.8 \times 133 \times r^4}{8 \times 4.0 \times 10^{-3} \times 2 \times 10^{-2}}$ (Correct substitution) ..... **(01)**

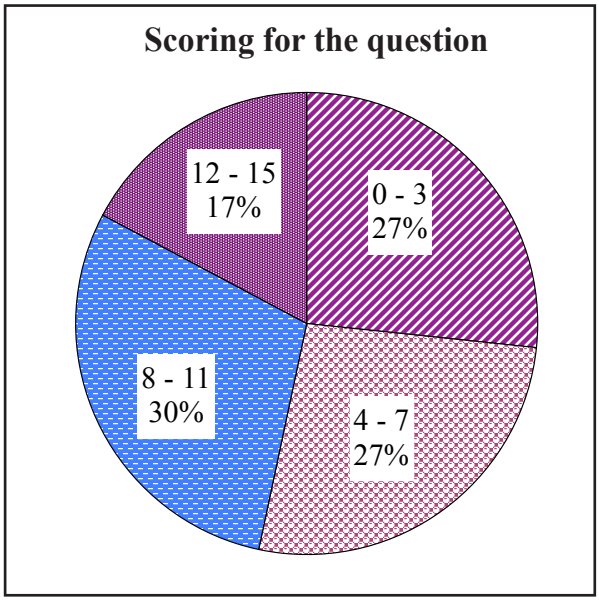
$r = 6.69 \times 10^{-4} m = 0.669\ mm$ ..... **(01)**

$(6.68 \times 10^{-4} m - 6.70 \times 10^{-4} m)$

(If $\pi = 3.14$ $r = 6.619 \times 10^{-4} m$
$(6.61 \times 10^{-4} m - 6.62 \times 10^{-4} m)$

(*e*) If the temperature inside a tube is reduced the viscosity will increase and hence the flow rate will decrease ..... **(01)**

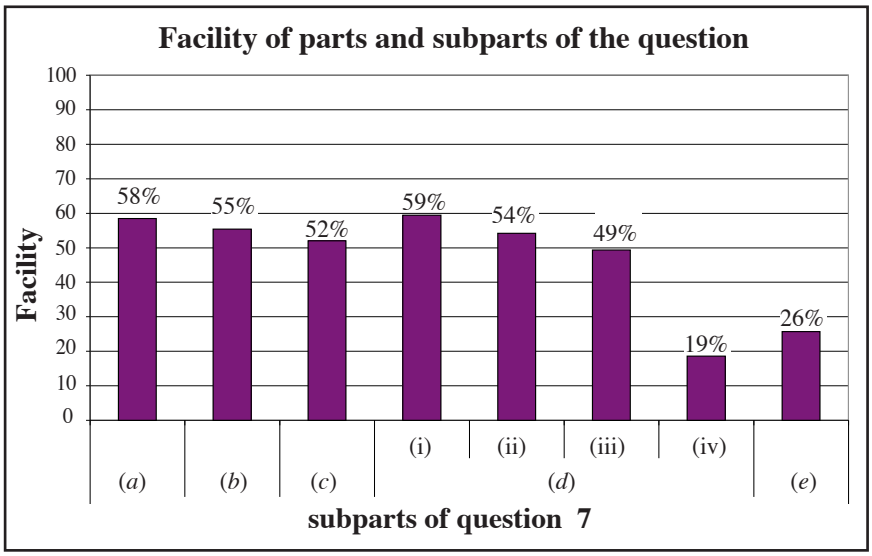
Summary of observations, conclusions and suggestions about answering question 7 :



A percentage as high as 61% is there for this question. It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 27%
Mark 4-7 class interval 27%
Mark 8-11 class interval 30%
Mark 12-15 class interval 17%

17% of the candidates have obtained 12 or more than 12 marks and 27% of the candidates have obtained 3 or less than 3 marks for this question.



There are 8 subparts in this question and facilities of 5 subparts are greater than 49%. The subpart with the lowest facility 19% is sub part (*d*) (iv) and the subpart with the highest facility 59% is (*d*) (i).

The question had been prepared from a subunit viscosity of the unit mechanical properties of matter. 61% of the candidates has answered the question. The question consits of 8 subparts and 6 subparts have a facility of 49% or more. The highest facility 59% is there for subpart (*d*)(i). The high achievent level shows the understanding regarding parallel and in-series flow tubes. subparts (*d*)(iv) has the lowest facility, which is 19%.

It may due to low level of achievement regarding substituting and simplifying the values after converting the units. Generally the achievement of this question is in a middle level.

8. Read the following passage and answer the questions.

Induction heating technology is of choice in many industrial, domestic and medical applications due to its advantages such as less heating time, localized heating, direct heating and efficient energy consumption. The operating principle of induction heating is based on the law of the electromagnetic induction discovered by Michael Faraday in 1831. The two major components in an induction heating system are a coil of wire (often a copper coil) producing a time varying magnetic field upon receiving a high frequency alternating current, and an electrically conducting material that generates heat. The magnetic field also changes its direction as the direction of the alternating current changes. When a conducting material is exposed to such a time-varying magnetic field, current loops called eddy currents are induced in the conducting material. As the magnetic field changes its direction rapidly the eddy currents also change their directions rapidly. The eddy currents always form closed loops inside conducting materials in planes perpendicular to the varying magnetic field. Eddy currents, generate Joule heat (I^2R type heat) due to the existence of resistance of the material.

When the magnetic field created is stronger or when the electrical conductivity is higher or when the rate of change of magnetic field is larger, the eddy currents that are developed become larger. The eddy currents which are generated by high frequency alternating current in the coil will exist only within a limited thickness near the surface of the material due to what is called skin effect.

The skin effect is the tendency of any high frequency electric current to distribute itself in a conductor with the current density being largest near the surface of the conductor and decreasing very rapidly with the depth of the conductor. This thickness across which eddy currents are distributed becomes even smaller due the mutual attraction between the alternating current in the coil and the eddy current loops. This is called the proximity effect. In addition to the Joule heating, an additional heat is also produced within the material due to a phenomenon called hysteresis effect. It occurs only in ferromagnetic materials such as some stainless steel, cast iron, nickel, etc. In response to the varying magnetic field produced by the alternating current, the magnetic domains in these materials repeatedly change their orientations. The energy required to turn them around finally is converted to heat. The rate at which the heat is generated due to hysteresis effect increases with the frequency of the varying magnetic field. Commercially available induction heating systems operate at frequencies approximately from 60 Hz to about 1 MHz and deliver power in the range from a few watts to several Megawatts.

The cookers that are available in the market as induction cookers operate on this principle. In an induction cooker, a coil of copper wire is mounted just under the surface of the cooker top where the cooking pot is placed, without touching it, and an alternating electric current is sent through the coil. The entire bottom of the cooking pot itself acts as the conducting material that generates the heat. The varying magnetic field produced by the coil enters the bottom of the cooking pot creating eddy currents and hysteresis losses, generating heat. In order to make use of both effects for heat generation, the cooking pots or the bottoms of the cooking pots are made of ferromagnetic materials such as some stainless steel or cast iron.

(*a*) State Faraday's Law of electromagnetic induction in words.

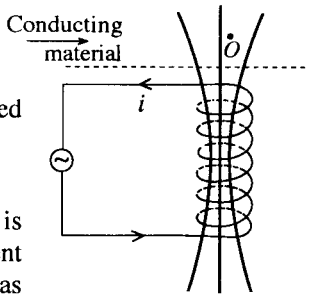
(*b*) Name **two** fields of application where induction heating is used.

(*c*) Write down the **two** heating processes involved in the induction heating.

(*d*) Write down **three** factors which give rise to larger eddy currents.

(*e*) Write down the **two** effects which limit the eddy currents to be within a limited thickness near the surface of the material.

(*f*) Copy the given diagram and answer the following questions.



The direction of the alternating current in a coil at a certain instant of time is shown in the figure. Consider a situation where the magnitude of this current is increasing with time. A conducting material is placed just above the coil as shown in the figure.

(i) Show the direction of the magnetic field created in this situation by drawing an arrow on one field line.

(ii) Draw one loop of eddy current in the material near the position O and show the direction of the eddy current when the alternating current is increasing.

(iii) Use Lenz's law to explain how you determined the direction of the eddy current loop that you have drawn in (ii) above.

(*g*) Explain how the increase of the frequency of alternating current, increases the rate of heating in the material.

(*h*) Consider a situation where a time-varying magnetic field enters a disk of radius R, thickness b and resistivity ρ. If the flux density B of the applied magnetic field varies sinusoidally as $B = B_0 \sin \omega t$ where B_0 is the amplitude of the flux density of the magnetic field, ω is the angular frequency and t is the time, then based on a very simplified model the average power P generated by the eddy currents in the disk can be given by $P = k B_0^2 \omega^2$ where $k = \frac{\pi R^4 b}{16\rho}$. If $k = 0.5$ m^4 Ω^{-1}, $\omega = 6000$ rad s^{-1} and $B_0 = 7.5 \times 10^{-3}$ T, calculate the average power generated in the disk.

(*i*) In transformers, the core is heated up due to eddy currents and it contributes to energy loss in the form of heat. How is this energy loss minimised in transformers?

(*a*) **Faraday's law** : The emf induced in a circuit is directly proportional to the time rate of change of magnetic flux through the circuit.

OR

When the magnetic flux connecting a circuit changes, an electromotive force is induced in the circuit proportional to the rate of change of the flux. ..... **(01)**

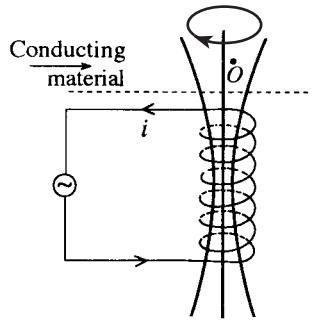
(*b*) Industrial, domestic and medical applications (Any two correct) ..... **(01)**

(*c*) Joule heating (I^2R type), Hysteresis effect (Change of orientation of magnetic domains) (Both correct) ..... **(01)**

(*d*) Magnetic field created is stronger, electrical conductivity is higher, the rate of change of magnetic field is larger. (All three correct) ..... **(01)**

(*e*) Skin effect, Proximity effect (Both correct) ..... **(01)**

(*f*) (i)



Drawing a correct arrow on a fields line as shown ..... **(01)**

(ii) Drawing an eddy current loop as shown ..... **(01)**
Showing the direction of the eddy current with an arrow. ..... **(01)**

(iii) According to the Lenz's law, the induced current and induced emf in a conductor are in such a direction as to set up a magnetic field that opposes the change in the magnetic field that produced them. ..... **(01)**

The magnetic field produced by the coil is increasing in the upward direction therefore to oppose this magnetic field the induced eddy current should be in the opposite direction of the current in the coil. ..... **(01)**

(*g*) The increase of the frequency of alternating current increase the rate of change of magnetic flux in the conducting material. ..... **(01)**

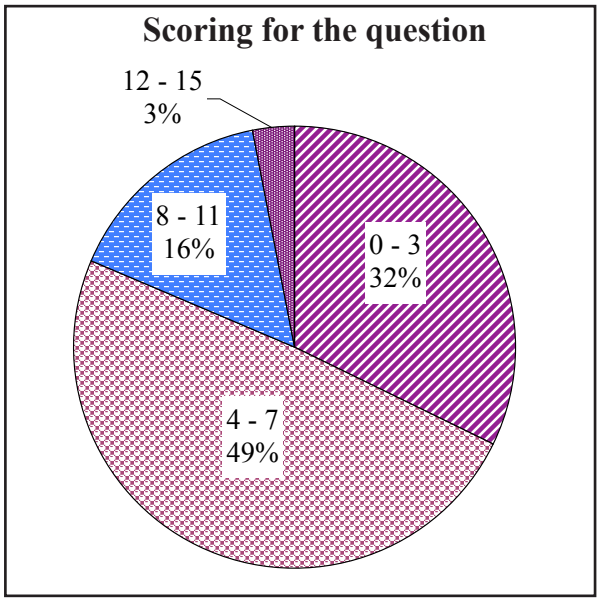
Increase in the rate of change of magnetic flux increases the magnitude of eddy current in the material. ..... **(01)**

(*h*) $P = kB_0^2\omega^2 = 0.5 \times (7.5 \times 10^{-3})^2 \times (6000)^2$ W = 1012.5 W **OR** P = 1013 W

Correct substitution ..... **(01)**
Correct answer ..... **(01)**

(*i*) The <u>core (conducting parts) is often laminated</u> (that is, they are built up in thin layers separated by a non – conducting material such as lacquer or a metal oxide) ..... **(01)**

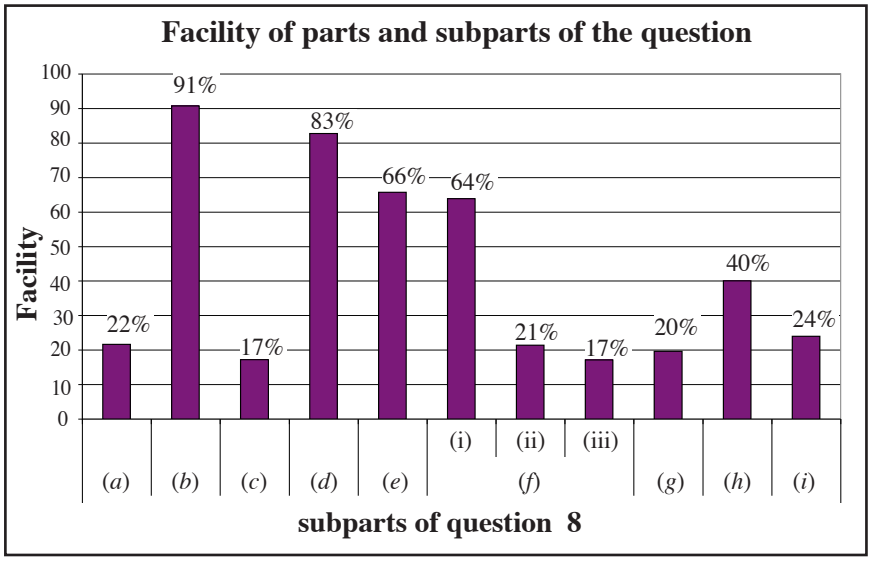
Summary of observations, conclusions and suggestions about answering question 8 :



72% of the candidates have selected this question. and it carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 32%
Mark 4-7 class interval 49%
Mark 8-11 class interval 16%
Mark 12-15 class interval 3%

Only 3% of the candidates have obtained 12 or more than 12 marks where as 32% have obtained 3 or less than 3 marks for this question.



There are 11 subparts in this question and 4 subparts. Out of them have a facility which is more than 64%. The subparts with lowest facility are (*c*) and (*f*)(iii) they are 17% each. The subpart with the highest facility is (*b*) and the facility of it is 91%.

The question has been prepared from the unit Electromagnetism. Although it is a comprehension type question any one cannot answer it without a proper understanding regarding the subject. Since the answer is already in the paragraph such questions had a facility of 91%. The facility of part (*c*) 17%. because most of the candidates had given only one answer although two answers were expected. Subpart (*f*)(iii) also had a facility of 17% due to a lower level of achievement regarding the definitions.

9. Answer either part (A) or part (B) only.

(A) (*a*) Write down an expression for the energy (W) dissipated in a resistor of resistance R when a current of magnitude I is passed through it for a period of time t.

(*b*) An electrical fuse is a small element consisting of a thin metal wire. Electrical fuses are connected in series with electrical/electronic circuits to avoid damages caused to them due to the passage of currents larger than the recommended current for the circuits (due to over-load currents and short circuits). When the current through the fuse in a certain circuit becomes larger than the recommended current in the circuit, the fuse burns (melts) and disconnects the circuit from the power source. The electrical fuses are selected so that their ratings are equal to the recommended currents in the circuits.

(i) Figure (1) shows how a fuse is connected to a circuit of load resistance R. Current in a certain fuse is rated as 5 A. If the length of the fuse wire is 3 cm, and its radius is 0.1 mm (area of cross-section $\sim 3 \times 10^{-8}\,m^2$) and the resistivity of the material of the wire at 25 °C is $1.7 \times 10^{-8}\,\Omega$ m, calculate the resistance of the fuse wire at room temperature of 25 °C.

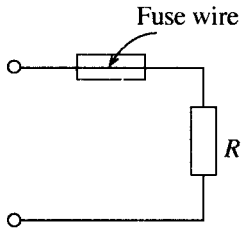


Figure (1)

(ii) When the fuse is operated at the rating mentioned in (i), at steady state, the entire heat generated by the fuse wire is dissipated to the surrounding without burning the fuse. Calculate the power dissipated by 5 A fuse in that manner. Take the average value of the resistance of the fuse wire over the temperature range is equal to five times the resistance calculated under (*b*)(i).

(iii) A test performed by manufacturers of electrical fuses is to determine the amplitude of a current pulse needed to melt (burn) the fuse wire approximately in one millisecond. Considering the rectangular current pulse of one millisecond duration shown in the figure (2), calculate the peak current I_0 of the pulse needed to melt the fuse wire given in (*b*)(i). Assume that the heat dissipation to the surroundings under this condition is negligible. Take the mass of the fuse wire given in (*b*)(i) as 7.5×10^{-6} kg, and the average value of resistance of the fuse wire as five times the resistance calculated under (*b*)(i). Specific heat capacity of the material of the fuse wire is 390 J kg^{-1} $°C^{-1}$. Melting point of the material of the fuse wire is 1 075 °C.

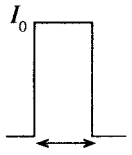


Figure (2)

(iv) Consider a situation in which a load circuit with an applied voltage of 230 V as shown in the figure (3) is short circuited at XY. Calculate the current through a 5 A fuse under this situation. Using the results obtained in (*b*)(iii), show that the fuse will melt before 1 millisecond. (Assume that the current produced is a rectangular current pulse.)

(v) A rectangular narrow current pulse of 500 A occurring for a duration of 1 μs passes through a 5 A fuse. In this situation, will the fuse get burnt? Justify your answer using an appropriate calculation.

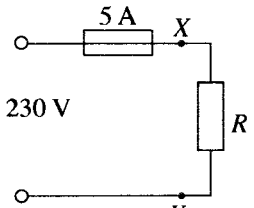


Figure (3)

(*a*) $W = I^2Rt$ ..... **(01)**

(*b*)(i) $R = \dfrac{\rho l}{A}$ ..... **(01)**

$= \dfrac{1.7 \times 10^{-8} \times 3 \times 10^{-2}}{3 \times 10^{-8}}$ (Correct substitution) ..... **(01)**

$= 1.7 \times 10^{-2}\,\Omega$ ..... **(01)**

(ii) $P = I^2R$

$= 5^2 \times (1.7 \times 10^{-2}) \times 5$ ..... **(01)**

$= 2.125$ W ..... **(01)**

(iii) $I_0^2 Rt = mc\,\Delta\theta$ ($mc\,\Delta\theta$ (Symbols have their usual meaning)..... **(01)**

(For equating mc $\Delta\theta$ to electrical energy)

$I_0^2 = \dfrac{(7.5 \times 10^{-6}) \times 390 \times 1050}{(1.7 \times 10^{-2}) \times 5 \times 10^{-3}}$ (Correct substitution) ..... **(01)**

$= 3.6132 \times 10^4$

$I_0 = 1.90 \times 10^2$ A (1.900×10^2 A – 1.901×10^2 A) ..... **(01)**

(iv) Current through 5 A fuse $= \dfrac{230}{1.7 \times 10^{-2} \times 5}$ ..... **(01)**

$= 2.706 \times 10^3$ A

(2.70×10^3 A – 2.71×10^3 A)

Since this current is greater than I_0 in part (iii), the fuse will melt before 1 millisecond ..... **(01)**

(A ward this mark for the above statement only if two respective current values are correct)

Alternative method :

If t is the time required to melt the fuse, then

$I^2 Rt = mc\,\Delta\theta$

$t = \dfrac{mc\,\Delta\theta}{I^2 R}$

$t = \dfrac{(7.5 \times 10^{-6}) \times 390 \times 1050}{(2.706 \times 10^3)^2 \times 1.7 \times 10^{-2} \times 5}$ ..... **(01)**

$= 4.93 \times 10^{-4}\ s$ ..... **(01)**

$= (4.93 - 4.94)$

$\therefore$ The fuse will burn before one millisecond. ..... **(01)**

(v) No

Justification :

Energy needed to melt the fuse wire $mc\,\Delta\theta = 7.5 \times 10^{-6} \times 390 \times 1050$ ..... **(01)**

$= 3.07$ J

Energy dissipated in the fuse $= 500^2 \times (1.7 \times 10^{-2}) \times 5 \times 10^{-6}$ ..... **(01)**

$= 2.125 \times 10^{-2}$ J

This value is very much less than the energy needed (3.07 J) to melt the wire. Therefore,

the fuse will not melt. ..... **(01)**
(For comparison of the above two values)

Alternative method :

If $\Delta\theta$ is the increase in temperature of the fuse, $\Delta\theta = \dfrac{I^2 Rt}{ms}$

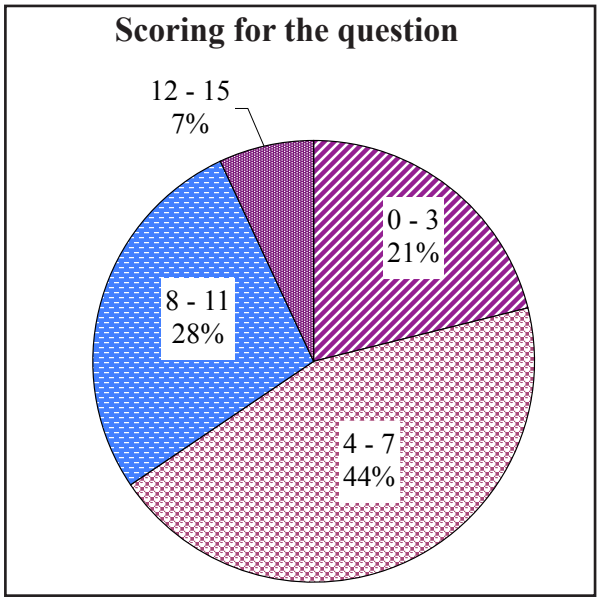
$$\Delta\theta = \frac{500^2\ (1.7 \times 10^{-2}) \times 5 \times 10^{-6}}{(7.5 \times 10^{-6}) \times 390}$$ ..... **(01)**

$= 7.26$ °C

$\therefore$ Final temperature attained by the fuse wire is $(25+7.26)°C = 32.26°C$ **(01)**

and it will not melt. ..... **(01)**

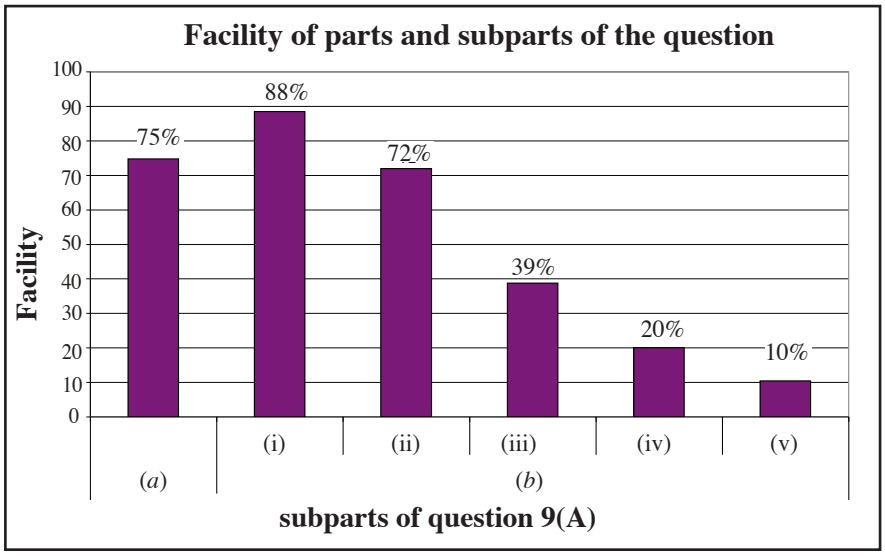
Summary of observations, conclusions and suggestions about answering question 9 (A) :



39% of the candidates have selected the question 9(A). It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 21%
Mark 4-7 class interval 44%
Mark 8-11 class interval 28%
Mark 12-15 class interval 7%

7% of the candidates have obtained 12 or more than 12 marks and 21% of the candidates have obtained 3 or less than 3 marks for this question.



There are 6 subparts in this question and 3 Out of them have exceeded the facility of 72%. Sub part with the lowest facility is (*b*)(v) and it was 10%. Subpart with the highest facility is (*b*)(i) and it is 88%.

The question has been prepared under the unit Current Electricity. 39% of the candidates has answered this question. There are 6 subparts to evaluate the candidates. The first three subparts have been answered by 72% or more. The achivement level of the candidates was at a higher level regarding the concepts in current Electricity, such as resistance power and conversion of Electrical energy in to heat energy. Lower facilities 20% and 10% were there for subparts (*b*)(iv) and (*b*)(v) respectively. It leads to conclude that the students show a lower level a achievement regarding the creative applications of Current Electricity. But subpart (*b*)(i) shows a facility of 88%. due to a proper understanding on the factors affecting on resistance of a wire.

(B) Figure (1) shows the circuit symbol of an operational amplifier having open loop voltage gain A.

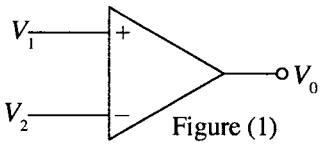


Figure (1)

(*a*) Write down the expression for the output voltage V_0 in terms of V_1, V_2, and A.

(*b*) If the positive and negative output saturation voltages of the operational amplifier are ± 15 V and $A = 10^5$, calculate the minimum input voltage difference which will drive its output into saturation.

(*c*) (i) Draw the output voltage waveform when the given triangular voltage signal of peak amplitude 5 V is applied to the + input of the circuit as shown in figure (2), and label its peak voltage values.

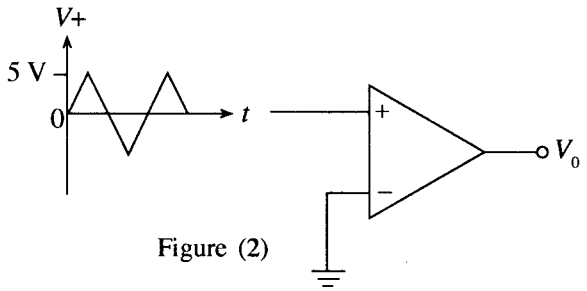


Figure (2)

(ii) The circuit in figure (2) is now modified as shown in figure (3). When S_1 is closed and S_2 is open the circuit will produce the output waveform shown in the figure (3) for the input triangular signal. Considering the actions of circuit elements in figure (3), explain the reasons for differences, if any, between the output voltage waveform shown in figure (3) and the waveform drawn by you in (*c*)(i). What is the peak voltage of the output in figure (3)?

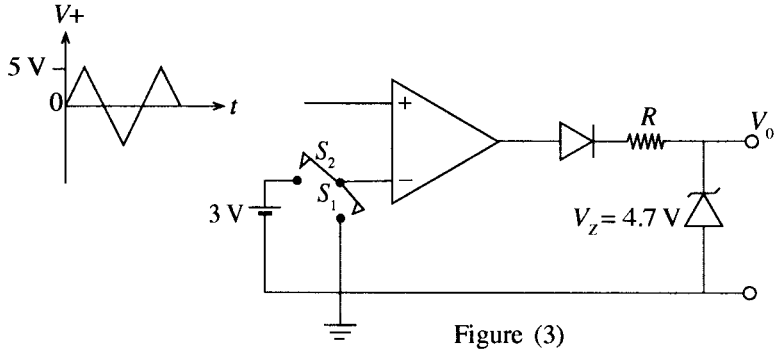
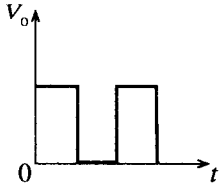


Figure (3)



(iii) Now a voltage of +3 V is applied to the – input of the operational amplifier in figure (3) by opening S_1 and closing S_2. When a hypothetical voltage waveform shown in figure (4) is applied to the + input of the operational amplifier, draw the output waveform expected from the circuit and label the magnitude of the output voltage.

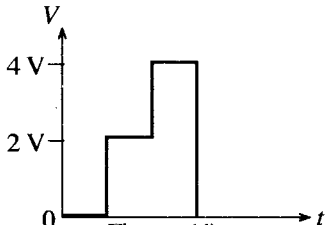


Figure (4)

(*d*) A certain blood cell counting system operates as follows. The blood is diluted by a known proportion in a proper type of solution, and allowed to flow through a small aperture X of the order of 50 μm diameter placed in between two electrodes S and T as shown in the figure (5). Blood cell counting is based on the fact that the electrical resistivity of blood cells is higher than the electrical resistivity of the solution.

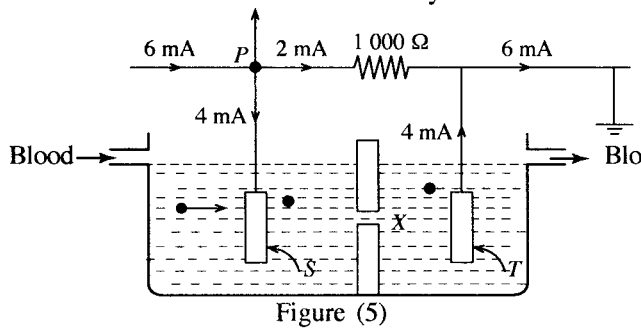


Figure (5)

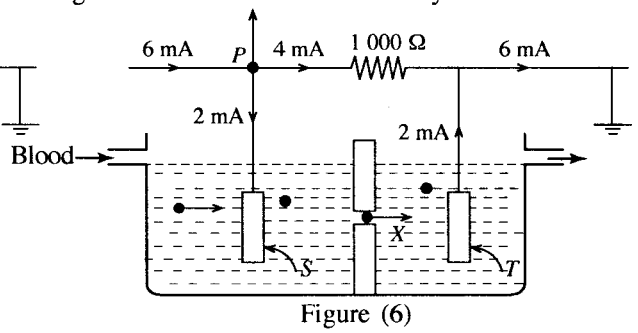


Figure (6)

A constant current of 6 mA is passed through the system as shown in figures (5) and (6). Currents through 1000 Ω resistor and the electrodes when the **solution** passes through the aperture X is shown in figure (5). Figure (6) shows the currents through 1 000 Ω resistor and the electrodes when a **blood cell** is going through the aperture X. The point P of the circuits shown in figures (5) and (6) is connected to + terminal of the operational amplifier in the circuit shown in figure (3) with S_1 open and S_2 closed. The output V_o is connected to a pulse counter. (Not shown in the figure.)

(i) What are the voltages at point P in figures (5) and (6)?

(iii) Draw the output voltage waveform of the circuit in figure (3) relevant to (ii) above.

(iv) What does the counter output indicate if a diluted blood stream is allowed to flow through the aperture *X*?

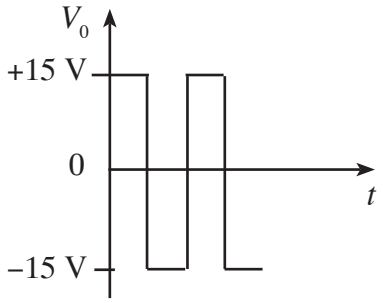
(*a*) $V_0 = A(V_1 - V_2)$ ..... **(01)**

(*b*) $(V_1 - V_2)_{min} = \frac{+15}{10^5}$ ..... **(01)**

$= 1.5 \times 10^{-4}\ V$ ..... **(01)**

(**OR** correct value in any other appropriate voltage units)

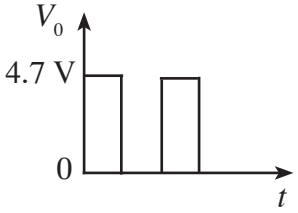
(*c*)(i)



A waveform symmetrical about *t* axis as shown ..... **(01)**

Labeling of peak voltage values ±15 V as shown ..... **(01)**

(ii)



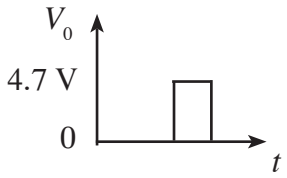
[Difference between two waveforms : (not asked)
(1) Out put waveform in c(i) has equal negative and positive half cycles but the waveform in c(ii) has only positive cycles.
(2) Peak voltage of the waveform in c(i) is (±)15V, but the peak voltage of the waveform in c(ii) is + 4.7 V]

Reasons :

(1) The diode is reversed biased during negative half cycles of the waveform, and does not allow the negative half cycle of the waveform to pass through. No current will pass through when it is in reversed biased ..... **(01)**

(2) Zener diode will limit the peak voltage of the output waveform in c(ii) to 4.7V ..... **(01)**

(iii) Output waveform



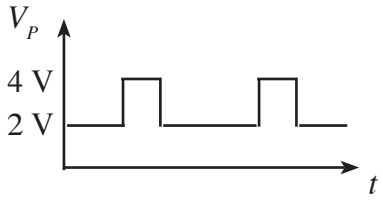
Output waveform as shown (a shape of pulse) ..... **(01)**

Magnitude of the output voltage (4.7 V) ..... **(01)**

(*d*) (i) Voltage at *P* in figure (5) = 2 V ..... **(01)**

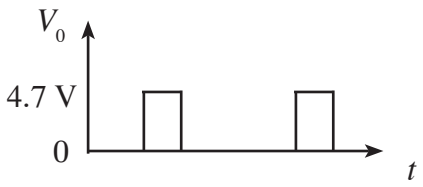
Voltage at *P* in figure (6) = 4V ..... **(01)**

(ii)



Shape of the waveform (single pulse is enough) ..... **(01)**

(iii)

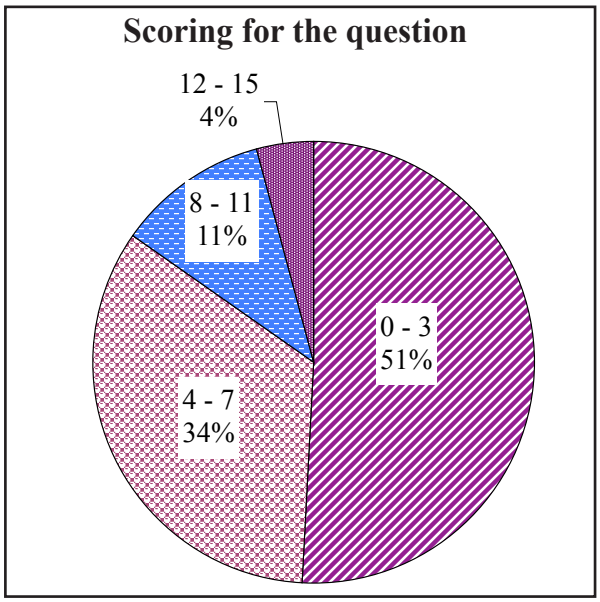


Output voltage waveform relevant to (ii) above, as shown (Single pulse is enough) ..... **(01)**

Labeling the peak voltage as above ..... **(01)**

(iv) The counter output indicates the number of blood cells passed through the aperture ..... **(01)**

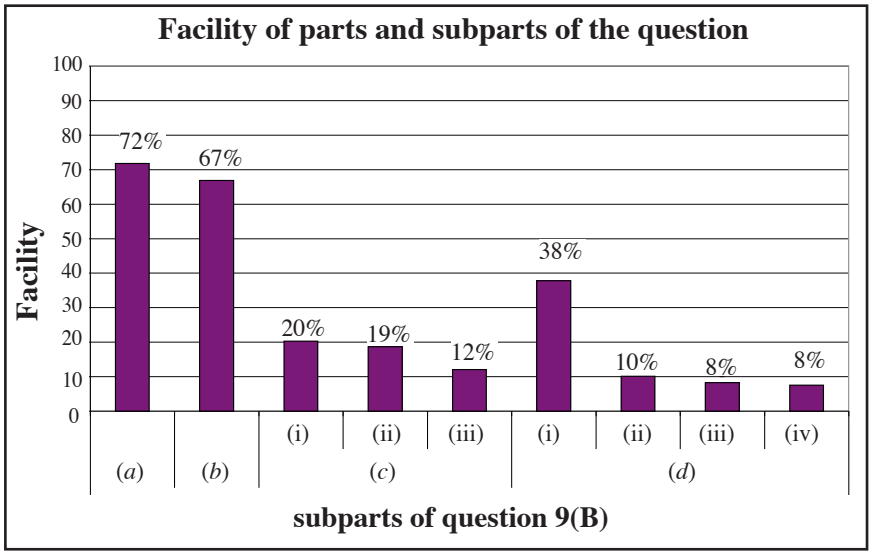
Summary of observations, conclusions and suggestions about answering question 9 (B) :



21% of the candidates have selected the question 9(B). It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 51%
Mark 4-7 class interval 34%
Mark 8-11 class interval 11%
Mark 12-15 class interval 4%

4% of the candidates have obtained 12 or more than 12 marks and 51% of the candidates have obtained 3 or less than 3 marks for this question.



There are 9 subparts in this question and 2 out of them have exceeded the facility of 67%. The subparts with a lowest facility are (*d*)(iii) and (*d*)(iv). The facilities of them are 8% each. The subpart with the highest facility is (*a*) and it is 72%.

The question has been prepared under the unit Electronics. 9 subparts are there to evaluate the candidates. It is concluded that the candidates have a sound understanding on operational amplifiers, because subparts (*a*) and (*b*) have the facilities of 72% and 67% respectively. The facilities of subparts (*d*)(ii), (*d*)(iii) and (*d*)(iv) are as low as 10%, 8% and 8% respectively. It may due to the inability of the candidates to understand the practical usage of this theory. Facilities of subparts (*c*)(i), (*c*)(ii) and (*c*)(iii) are 20% or less than that. It is because of a lower achievement level regarding plotting the relevant graphs. Generally this question has a lower level of facility. Therefore it is very important to draw a considerable attention towards creative applications of Electronics.

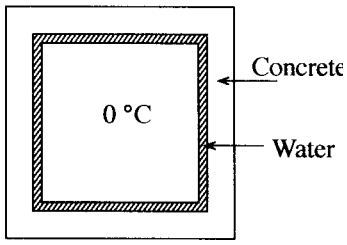
10. Answer either part (A) or part (B) only.

(A) (*a*) (i) Briefly explain how heat is absorbed when the physical state of a material is changed from solid state to the liquid state.

(ii) 10 mega Joules of excess thermal energy produced by a certain thermal power plant is to be stored as latent heat in an insulated **solid** block of zinc which is maintained at its melting point of 420 °C. If the entire excess energy is used to melt zinc, calculate the minimum mass of solid zinc necessary for this purpose.

Specific latent heat of fusion of zinc is 1.15×10^5 J kg^{-1}.

(*b*) The temperature inside a certain outdoor closed storage room in a cold country is to be maintained at 0 °C when the outside temperature is at –30 °C. The room is thermally insulated with 20 cm thick concrete walls. The inner surfaces of the walls are in contact with a uniform water layer of sufficient thickness maintained at 0 °C as shown in the figure. Water is stirred internally to avoid formation of static frozen ice layers. (Assume that the stirring process does not add any heat to water.)



(i) Explain briefly how the temperature of the room can be maintained in 0 °C upto sometime using this method.

(ii) Calculate the minimum mass of the water layer which will ensure that the 0 °C temperature is maintained in the room upto 10 hours and only 25% of the mass of water is converted to ice during this time period.

Total mean surface area of all the walls is 120 m^2.
Thermal conductivity of concrete = 0.8 W m^{-1} °C^{-1}. Specific latent heat of fusion of ice = 3.35×10^5 J kg^{-1}.

(iii) Suppose the above mentioned entire water layer is frozen due to some unforseen reason and a uniform ice layer of thickness 5 cm is formed on the inner surface of concrete walls. Calculate the rate at which the heat from the 0 °C room begins to flow out as soon as the ice layer is formed. Thermal conductivity of ice = 2.2 W m^{-1} °C^{-1}. For calculations, assume that the total mean surface area of the ice layer through which the heat flows out is also 120 m^2.

(*a*) (i) The latent heat is partly used to overcome the forces of attraction between the molecules. ..... **(01)**

(ii) The minimum mass m required is given by,

$m \times 1.15 \times 10^5 = 10 \times 10^6$

$m = 86.95$ kg (86.95 – 86.96) ..... **(01)**

(*b*) (i) Latent heat of water is capable of compensating the heat loss through concrete without changing the temperature of water or room. ..... **(02)**

(02 Or Zero)

(ii) Amount of heat lost (Q) through concrete given by,

$$Q = 0.8 \times 120 \times \frac{30}{20 \times 10^{-2}} (3600 \times 10)$$ ..... **(01)**

Use of equation $\frac{dQ}{dt} = kA \frac{d\theta}{dL}$ in the above expression ..... **(01)**

$Q = 5.184 \times 10^8$ J

If the minimum mass needed is m

Heat to be given out by water $= m \times 120 \times \frac{25}{100} \times 3.35 \times 10^5$ ..... **(01)**

(For multiplying the above expression by $\frac{25}{100}$)

$\therefore m \times \frac{25}{100} \times 3.35 \times 10^5 = 5.184 \times 10^8$ ..... **(01)**

(for equating the two expression)

$m = 6.190 \times 10^3 \text{ kg}$ ..... **(01)**

$= (6.189 \times 10^3 - 6.191 \times 10^3)$

(iii) Let θ be the temperature at the ice-concrete interface. Then,

$$\left.\begin{aligned} \frac{dQ}{dt} &= k_1 A \ \frac{0-\theta}{L_1} \\ &= k_2 A \ \frac{\theta-(-)30}{L_2} \end{aligned}\right\}$$ ..... **(01)** (For both equations)

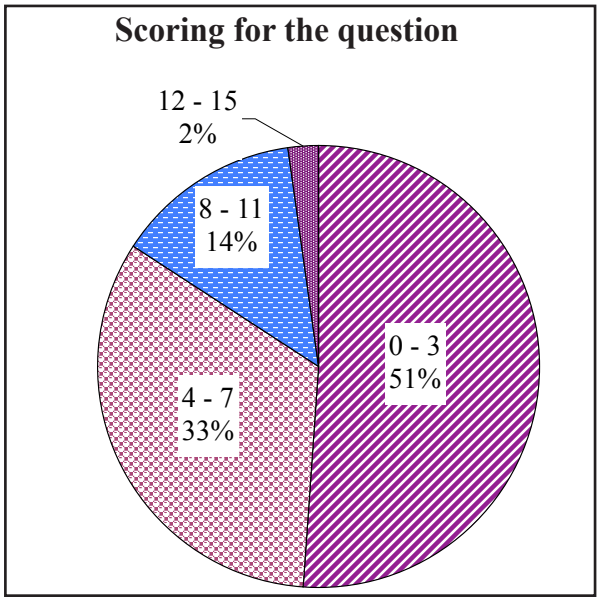
$$\left(\frac{L_1}{k_1 A} + \frac{L_2}{k_2 A}\right)\frac{dQ}{dt} = 30$$ ..... **(01)**

$$\left(\frac{5 \times 10^{-2}}{2.2 \times 120} + \frac{20 \times 10^{-2}}{0.8 \times 120}\right)\frac{dQ}{dt} = 30$$ ..... **(01)**

$$\frac{dQ}{dt} = 1.320 \times 10^4 \text{ Js}^{-1}$$ ..... **(01)**

$(1.319 \times 10^4 - 1.320 \times 10^4)$ ..... **(01)**

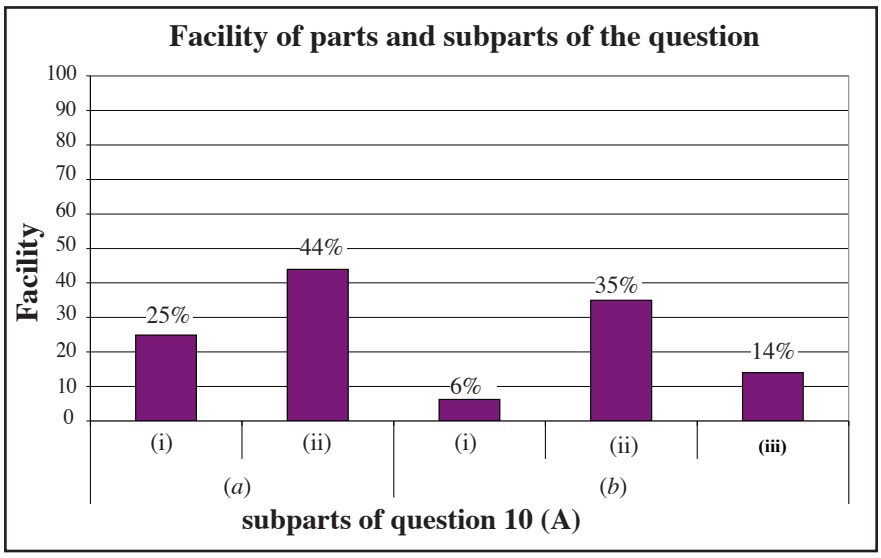
Summary of observations, conclusions and suggestions about answering question 10 (A) :



Since this was not a compulsory question 45% of the candidates in the sample have selected it. The question carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 51%
Mark 4-7 class interval 33%
Mark 8-11 class interval 14%
Mark 12-15 class interval 2%

2% of the candidates have obtained 12 or more than 12 marks and 51% of the candidates have obtained 3 or less than 3 marks for this question.



There are 5 subparts in this question and one part has exceeded a facility of 35%. The subpart with the lowest facility is (*b*)(i) and it is 6%. The subpart with the highest facility is (*a*)(ii) and it is 44%.

The question has been prepared under the unit Thermal Physics. Although this is a very popular unit, only 45% of the candidates have answered it. There are five subparts to evaluate the knowledge regarding heat transfer. Facility of part (*a*) is as low as 25%. Therefore it concludes that the students have a lower level of achievement regarding the nature of occuring latent heat. Subpart (*a*)(ii) has a facility of 44%. It shows that the candidates have an enough understanding on the equation of latent heat. The facility of subpart (*b*)(i) is as low as 6%. It is due to insufficient knowledge regarding the need of external energy supply to control the latent heat. That means they do not have direct understanding on energy loss. Subpart (*b*)(ii) has a facility of 35% due to inconsistancy of substituting and simplification, though they have a good understanding regarding the equations of heat conduction, up to the end of the question. The facility of subpart (*b*)(iii) is as low as 14% because of the incorrect application of heat conductance across a compound rod. The level of proficiency can be improved by engaging in relevant exersises frequently.

(**B**) Radioisotope Thermoelectric Generators (RTGs) are used to generate electricity in space-crafts, satellites etc. An RTG consists of two subsystems.

(1) Thermal source:
It is a container of alpha particle emitting radioactive source. The kinetic energy produced by all the alpha particles is converted to thermal energy and absorbed by the container.

(2) Energy conversion system:
It is a thermoelectric generator which converts thermal energy absorbed by the container into electrical energy.

Consider an RTG of a certain space-craft which uses ^{238}Pu in the form of plutonium oxide (PuO_2) as the radioactive source. The radioactive source contains 2.38 kg of PuO_2 for which the fraction of ^{238}Pu in PuO_2 is 0.9 at the launch of the space-craft. The thermal energy absorbed per radioactive decay of ^{238}Pu by the container is 5.5 MeV. Half life of ^{238}Pu is 87.7 years and the corresponding decay constant is 0.0079 y^{-1} (= 2.5×10^{-10} s^{-1}). Avogadro number is 6.0×10^{23} atoms per mole.

(i) Find the initial activity in Bq of the radioisotope source at the launch of the space-craft.

(ii) If the efficiency of conversion of thermal power into electrical power is 7%, find the electrical power in the RTG at the launch of the space craft (1 MeV = 1.6×10^{-13} J).

(iii) Find the activity of the radioisotope source by the end of the 10 years mission of the space-craft. (Take $e^{-0.079} = 0.92$)

(iv) Find the electrical power produced by the RTG at the end of the mission.

(v) Find the percentage loss of the electrical power after the mission.

(vi) Give **one** advantage of using RTGs in space-crafts.

(i) The amount of ^{238}Pu in the source $= 2380 \times 0.9g$ ..... **(01)**

No.of atoms in the source $No = \dfrac{2380 \times 0.9 \times 6.0 \times 10^{23}}{238}$ ..... **(01)**

$$N_o = 5.4 \times 10^{24} \text{ atoms}$$

Initial activity $A_o = N_o\lambda$ ..... **(01)**

$= 5.4 \times 10^{24} \times 2.5 \times 10^{-10} s^{-1}$ ..... **(01)**

$= 1.35 \times 10^{15}$ Bq ..... **(01)**

(ii) Let E = Energy absorbed by the container in one decay

Thermal power produced $= A_oE$ ..... **(01)**

$A_oE = 1.35 \times 10^{15} \times 5.5 \times 1.6 \times 10^{-13}$ ..... **(01)**

$= 1188$ W

Electric power produced at the launch of the space craft

$= 1188 \times \dfrac{7}{100}$ ..... **(01)**

$= 83.2$ W ..... **(01)**

$= (83.1 \text{ W} - 83.2 \text{ W})$

(iii) Activity of the source after 10 years of the mission (A),

$A = A_o e^{-\lambda t}$

$= 1.35 \times 10^{15} \times e^{-0.0079 \times 10}$

(Writing equation or substitution) ..... **(01)**

$= 1.35 \times 10^{15} \times 0.92$

$= 1.24 \times 10^{15}$ Bq ..... **(01)**

(iv) Electric power produces by the RTG at

end of the mission $= 1.24 \times 10^{15} \times (5.5 \times 1.6 \times 10^{-13}) \times \frac{7}{100}$

OR $83.2 \times \frac{A}{A_o} = \frac{83.2 \times 1.24 \times 10^{15}}{1.35 \times 10^{15}}$ ..... **(01)**

$= 76.4$ W ..... **(01)**

(76.3 – 76.5)

(v) Percentage loss of electric power after the mission $= \frac{83.2 - 76.4}{83.2} \times 100$

$= 8\%$ ..... **(01)**

$= (8\% - 8.2\ \%)$

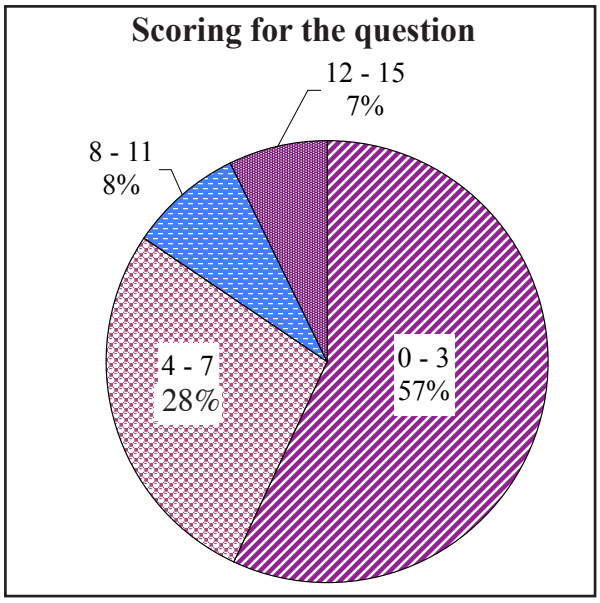
(vi) 1. RTG can be used when solar energy is not available

2. Can Get electric power for a longer period in compared with other electrical sources.

3. Can be used without maintenance

Any of the above ..... **(01)**

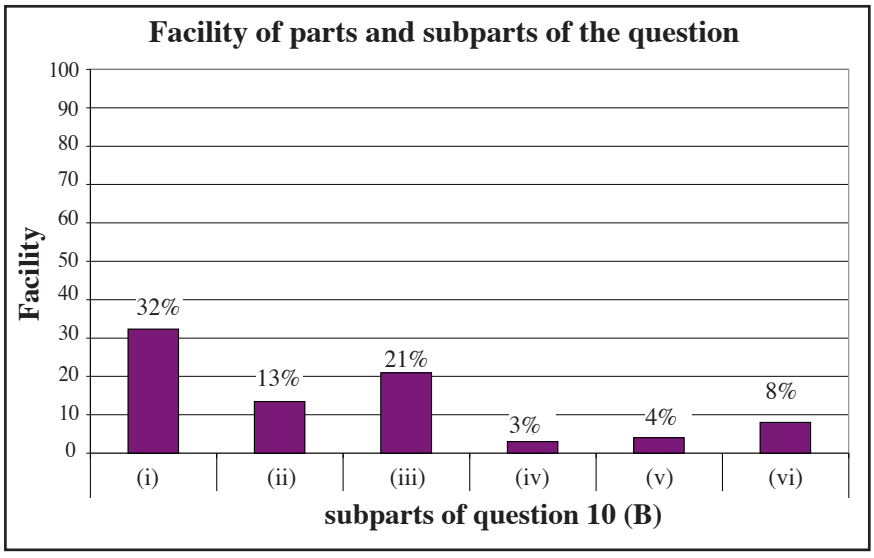
Summary of observations, conclusions and suggestions about answering question 10 (B) :



Since this is not a compulsory but a selective question, less than 8% of the candidates have answered. It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 57%
Mark 4-7 class interval 28%
Mark 8-11 class interval 8%
Mark 12-15 class interval 7%

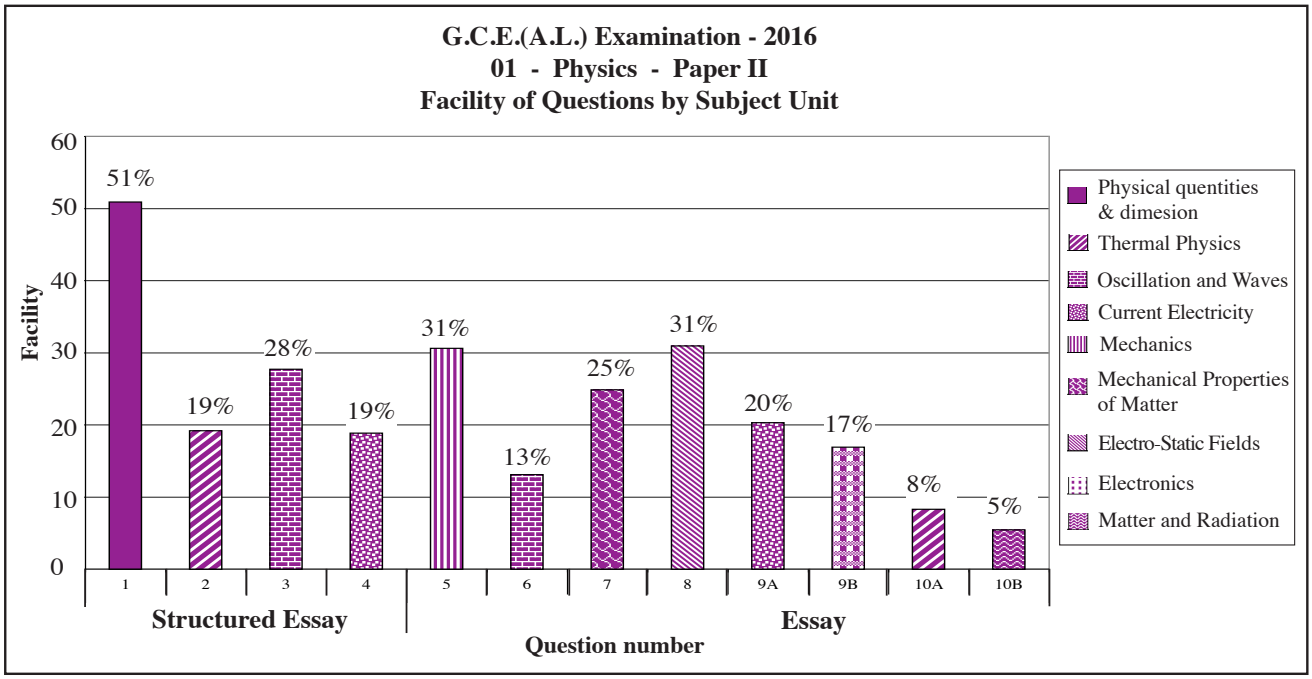
7% of the candidates have obtained 12 or more than 12 marks and 57% of the candidates have obtained 3 or less than 3 marks for this question.



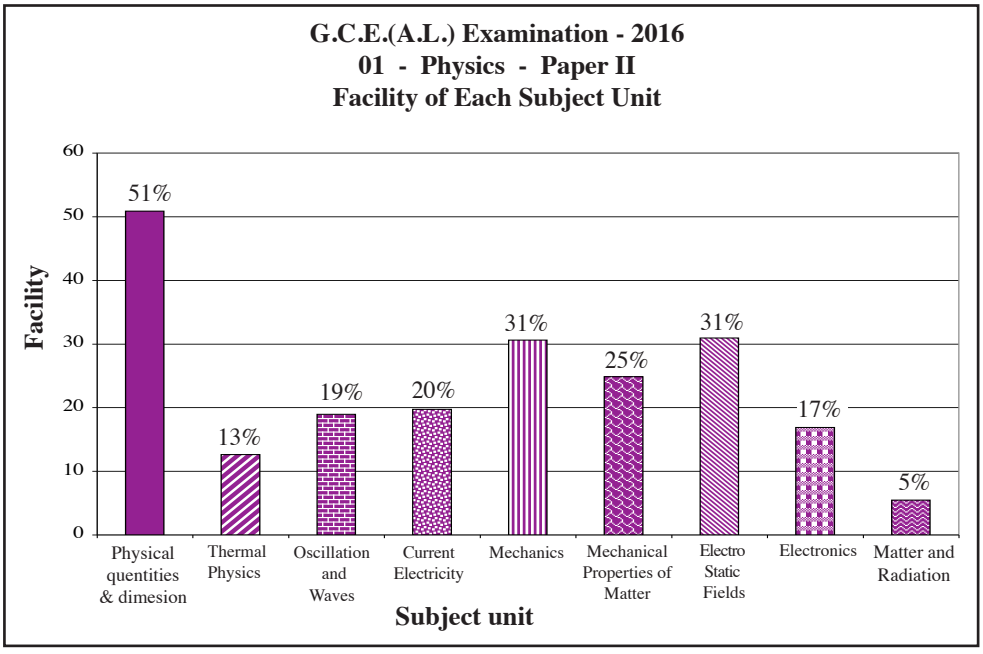
There are 6 subparts in this question. Out of them one subpart has exceeded the facility of 21%. The subpart with the lowest facility is (iv) and it is 3%. The subpart with the highest facility is (i) and it is 32%.

This question has been prepared under the unit number 11, Matter and Radiation. 8% of the candidates have answered this question. It was a question with a less popularity, among the candidates. Subpart (i) shows the greatest facility out of the six subparts and it is 32%. All the other subparts show a lower facility than 32%. Subpart (v) shows a facility which is as low as 4% due to the effect of incorrect answers obtained for parts (ii) and (v). Part (iv) has a lower facility of 3%, because of the lower level of achievement regarding determining the power using the answes obtained in parts lower facility of 3%, because of the (ii) and (iii) for the activity of radioisotope source and electrical power generated by RTG at the launching of the space craft.

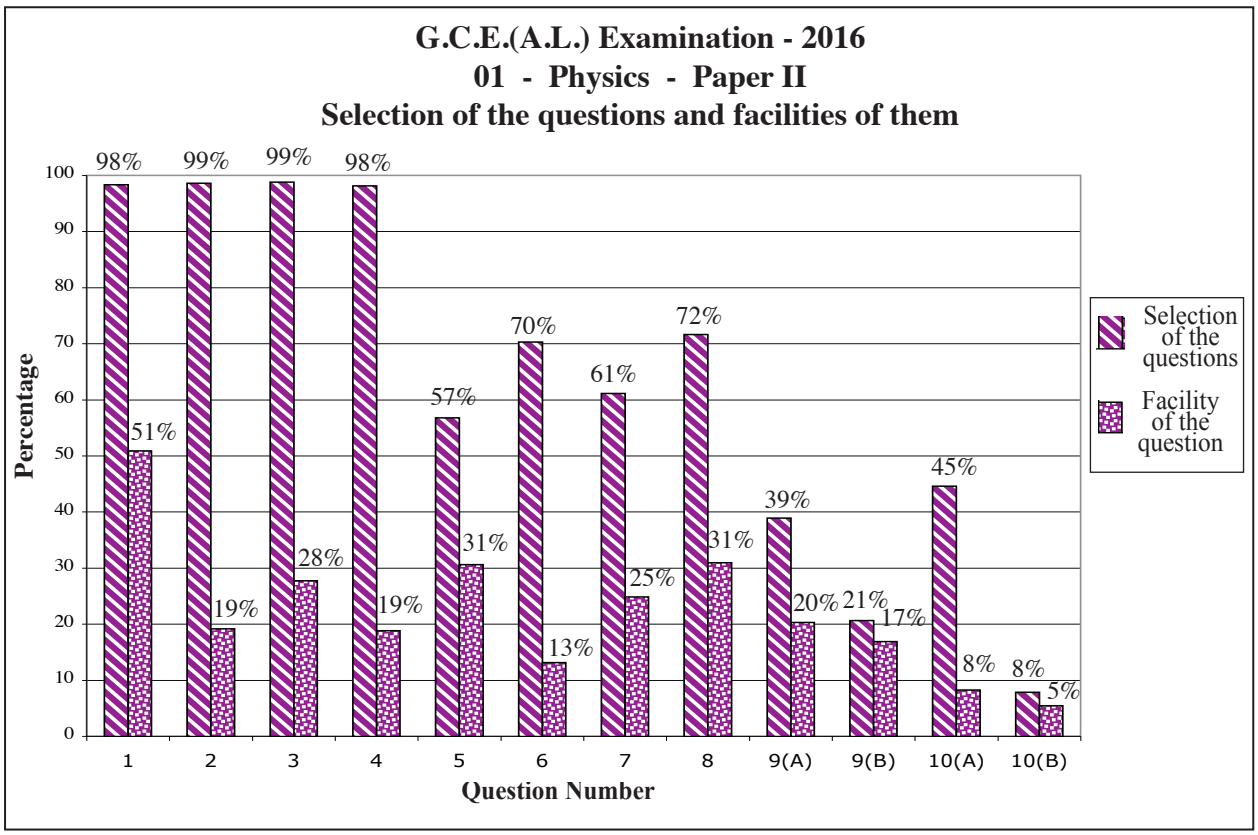
2.2.3 Overall observations, conclusions and suggestions regarding the answers to paper II



The Facilities of the questions in paper II ranges from 5% to 51%. Among them only the question number 1 has obtained a facility which is greater than 50%. It is a creative type question. The question with the greatest difficulty is question 10(B). The facility of it is 5%. There are about 8 questions between 19% and 31% facilities.



Among all the questions the highest facility of 51% is there for question number 1 which is from the unit Measurement. The question with the least facility 5% is question number 10(B).



Question number 1, 2, 3 and 4 are compulsory and they are structured essay type questions. Percentages of selection of them are 98%, 99%, 99% and 98%. But facilities of them are 51%, 19%, 28% and 19% respectively. A least number of students have selected question number 10(B). Facility of it is 5%. Reason for a reduced facility could be poor realization of the relevant theories, lack of broad understanding regarding the mathamtical operations and insufficient attention for the theories, since it is the last unit of the syllabus. The greatest facility 51% is there for the question number 1 which is a structured essay type question. All the essay type questions in paper II had a facility less than 31%.

Question number 5 and 8 which are essay type questions show an equal facility of 31%. Question number 6 shows a facility of 13%. It is due to insufficient study regarding eye defects and remedies for them.

Part III

3. Facts to be considered when answering questions and suggestions :

3.1. Facts to be considered when answering :

General instructions:

* Basic Instructions given in the question paper must be carefully read and understood before starting to answer. The facts such as how many questions have to be answered, which questions are compulsory, the time allocated and the amount of marks allotted for the questions must be taken into consideration and the questions should be read and understood before selecting.
* For each of the questions in paper I, only the most appropriate answer should be selected and marked with only one cross clearly on the answer sheet.
* Answering for each major question of paper II must be started in a new page.
* Answering must be done with correct and clear hand writing.
* Index Number of the candidate must be written in the relevant place of each page.
* The question number and its parts and the subpart must be indicated accurately.
* Explanatory answers must not be given where short answers are expected and vice- versa.
* The facts must be presented logically and analytically according to the question.
* All the parts and subparts of the major question must be read well in answering the paper II and only the expected answer containing the relevant points should be written.
* It is necessary to manage the allotted time for each of the questions.
* Red colour pens or Green colour pens should not be used to write the answers.
* The students must be trained to answer the whole question continuously without writing them here and there.
* If a quantity has to be subjected it should be done accordingly.

Special instructions:

* The numerical values given in the questions must be used to make the simplifications of the calculations easy.
* Diagrams must be drawn very clearly and labelled where ever necessary.
* The steps of calculations must be clearly given in the order.
* The units must be used accurately where ever necessary
* When ray-diagrams are drawn, the directions must be indicated using arrow-heads.
* In graphs, the axes x and y must be labelled accurately and the units should be indicated where necessary
* If the important points are marked while reading the questions containing long paragraphs, the time would be managed efficiently.
- It will be easy to answer within the given time by following the given instructions properly.
- Having understood the fact that the provided space is enough to write a correct answer in structured essay questions, the answering should be done.
- It will be easy to reach the correct answers by using the numerical data given in the question itself when simplifying.

3.2. Comments and Suggestions regarding the Learning and Teaching Process :

* **To improve the results through Learning, Teaching and Evaluation process :**

- The teacher must initiate the teaching process having a clear understanding about the theories and principles in physics and related phenomena which are applied in day-to-day life.
- It can be realised that students' understanding regarding the subject Physics is insufficient When the style of answering is considered for the question paper in G.C.E.(Advanced Level) Examination. Since the principles and concepts have not been formed correctly, the weakness of ability to understand the questions accurately can be seen. If the scientific method is appropriately used in the teaching learning process in the classroom, students can achieve a number of competencies.
- It is easy to direct the students towards the relevant goals by leading the teaching learning process through practical activities.
- It is suitable to use the modern technological resources such as computer software, internet related web sites and instruments such as multi-media projectors to establish the subject knowledge.
- Students must be guided to collect additional knowledge by using supplementary books and resources related to the syllabus.
- The skills of answering questions must be developed in students by making them engaged in working out tutorials.
- Students must be trained to give the final answer to the nearest two decimal places correctly where necessary.
- Students must be trained to apply the theoretical knowledge in practical situations.
- It is suitable to train the students for the questions containing long paragraphs by doing the past examination questions and by conducting disscusions
- Reading the question paper properly
- Understanding the structure of the question
- Through correct simplifications
- By comparing the answer obtained with the answers given a higher achievement level can be reached. For that

  1. Ability to memorise the theories in each unit
  2. Practicing the exercises
  3. Guidance of the teachers to elaborate the graphs are essential.

- The students must be guided to reach a higher achievement level in theories by engaging them properly in laboratory practicals.

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