G.C.E.(A.L.) Examination - 2012

Evaluation Report

01 - Physics

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

Physics
Evaluation Report - G.C.E.(A.L.) Examination - 2012

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 bears a momentous position as an achievement test as well as a selection test because the eligible candidates for national universities and other higher education and vocational training institutes and also for the National Colleges of Education are selected on the results of this examination. This has also been accepted as an examination that certifies entry qualifications for the tertiary level employments. In the year 2012, 196954 school candidates and 10954 private candidates sat this examination.

Much pains are being taken by students to have a high achievement level at this examination and teachers and parents to fulfil their expectations. This evaluation report has been prepared by the Department of Examinations to assist the realization 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. So it is appropriate to tender 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. Presented under it are the statistical information on subject achievement, that is number of candidates sat for the subject, how they have obtained grades, how school candidates have obtained grades by district and distribution of marks according to class intervals and 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 in them and the sub parts of each question. Part II of this report presents the questions in Paper I and Paper II of Physics in the G.C.E. (A.L) Examination 2012 and information about the candidates' responses to them. It encompasses expected answers for the questions of papers I and II, the scheme of marking, observations on answers, conclusions and constructive suggestions.

This evaluation report prepared by the Research and Development Branch of the Department of Examinations is based on the information, observations, ideas and suggestions provided by chief examiners, additional chief examiners and assistant examiners 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 with regard to the learning teaching process. I think that this report is of immense value in the organization of 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 sincere thanks to the chief examiners, additional chief examiners and assistant examiners who provided information to prepare this report, the committee members who fervently and actively contributed to the task, the officers and the staff of the Department of Examinations who shouldered the responsibility, State Printing Co-operation who printed this material and the TSEP-WB that provided financial assistance for it.

W.M.N.J. Pushpakumara
Commissioner General of Examinations

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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 become a confident citizen in a technological world.
2. recognizes the usefulness and limitations of scientific method and to appreciate its applicability in everyday life.
3. develops abilities and skills that are relevant to the study and practice of Physics in day-to-day life.
4. develops attitudes relevant to Physics such as concern for accuracy and precision, objectivity, enquiry, initiative and inventiveness.
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	41493	538	42031
Tamil	6404	154	6558
English	2929	159	3088
Total	**50826**	**851**	**51677**

Table 1

1.2.2 Grades obtained by the candidates

Grade	School Candidates		Private Candidates		Total	Percentage
	Number	Percentage	Number	Percentage		
A	2821	5.55	29	3.41	2850	5.51
B	4650	9.15	47	5.52	4697	9.09
C	12009	23.63	119	13.98	12128	23.47
S	16029	31.54	224	26.32	16253	31.45
F	15317	30.14	432	50.76	15749	30.48
Total	**50826**	**100.00**	**851**	**100.00**	**51677**	**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	5354	436	8.14	544	10.16	1354	25.29	1536	28.69	3870	72.28	1484	27.72
2. Gampaha	2832	128	4.52	210	7.42	620	21.89	870	30.72	1828	64.55	1004	35.45
3. Kalutara	1805	66	3.66	120	6.65	342	18.95	615	34.07	1143	63.32	662	36.68
4. Kandy	2123	126	5.93	185	8.71	484	22.80	645	30.38	1440	67.83	683	32.17
5. Matale	479	18	3.76	28	5.85	108	22.55	152	31.73	306	63.88	173	36.12
6. Nuwara Eliya	631	13	2.06	34	5.39	109	17.27	205	32.49	361	57.21	270	42.79
7. Galle	1996	99	4.96	128	6.41	409	20.49	604	30.26	1240	62.12	756	37.88
8. Matara	1696	100	5.90	108	6.37	291	17.16	508	29.95	1007	59.38	689	40.63
9. Hambantota	1082	45	4.16	47	4.34	145	13.40	313	28.93	550	50.83	532	49.17
10. Jaffna	1147	67	5.84	98	8.54	227	19.79	322	28.07	714	62.25	433	37.75
11. Kilinochchi	84	3	3.57	7	8.33	11	13.10	27	32.14	48	57.14	36	42.86
12. Mannar	122	2	1.64	2	1.64	22	18.03	45	36.89	71	58.20	51	41.80
13. Vavuniya	171	9	5.26	16	9.36	41	23.98	44	25.73	110	64.33	61	35.67
14. Mullativu	89	3	3.37	1	1.12	14	15.73	25	28.09	43	48.31	46	51.69
15. Batticaloa	494	25	5.06	36	7.29	112	22.67	158	31.98	331	67.00	163	33.00
16. Ampara	865	27	3.12	44	5.09	175	20.23	320	36.99	566	65.43	299	34.57
17. Trincomalee	331	9	2.72	18	5.44	54	16.31	106	32.02	187	56.50	144	43.50
18. Kurunegala	2215	68	3.07	131	5.91	437	19.73	707	31.92	1343	60.63	872	39.37
19. Puttalam	730	19	2.60	66	9.04	158	21.64	218	29.86	461	63.15	269	36.85
20. Anuradhapura	971	22	2.27	45	4.63	155	15.96	296	30.48	518	53.35	453	46.65
21. Polonnaruwa	357	13	3.64	17	4.76	63	17.65	123	34.45	216	60.50	141	39.50
22. Badulla	990	38	3.84	68	6.87	208	21.01	346	34.95	660	66.67	330	33.33
23. Monaragala	376	6	1.60	12	3.19	65	17.29	129	34.31	212	56.38	164	43.62
24. Ratnapura	1408	51	3.62	83	5.89	269	19.11	456	32.39	859	61.01	549	38.99
25. Kegalle	1200	13	1.08	74	6.17	216	18.00	408	34.00	711	59.25	489	40.75
All Island	**29548**	**1406**	**4.76**	**2122**	**7.18**	**6089**	**20.61**	**9178**	**31.06**	**18795**	**63.61**	**10753**	**36.39**

Table 3

1.2.4 Marks obtained according to class intervals

Class Interval	Frequency	Frequency Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91 - 100	49	0.09	51677	100.00
81 - 90	1054	2.04	51628	99.91
71 - 80	3340	6.46	50574	97.87
61 - 70	5799	11.22	47234	91.40
51 - 60	8386	16.23	41435	80.18
41 - 50	10661	20.63	33049	63.95
31 - 40	10853	21.00	22388	43.32
21 - 30	8420	16.29	11535	22.32
11 - 20	3010	5.82	3115	6.03
01 - 10	104	0.20	105	0.20
00 - 00	1	0.00	1	0.00

Table 4

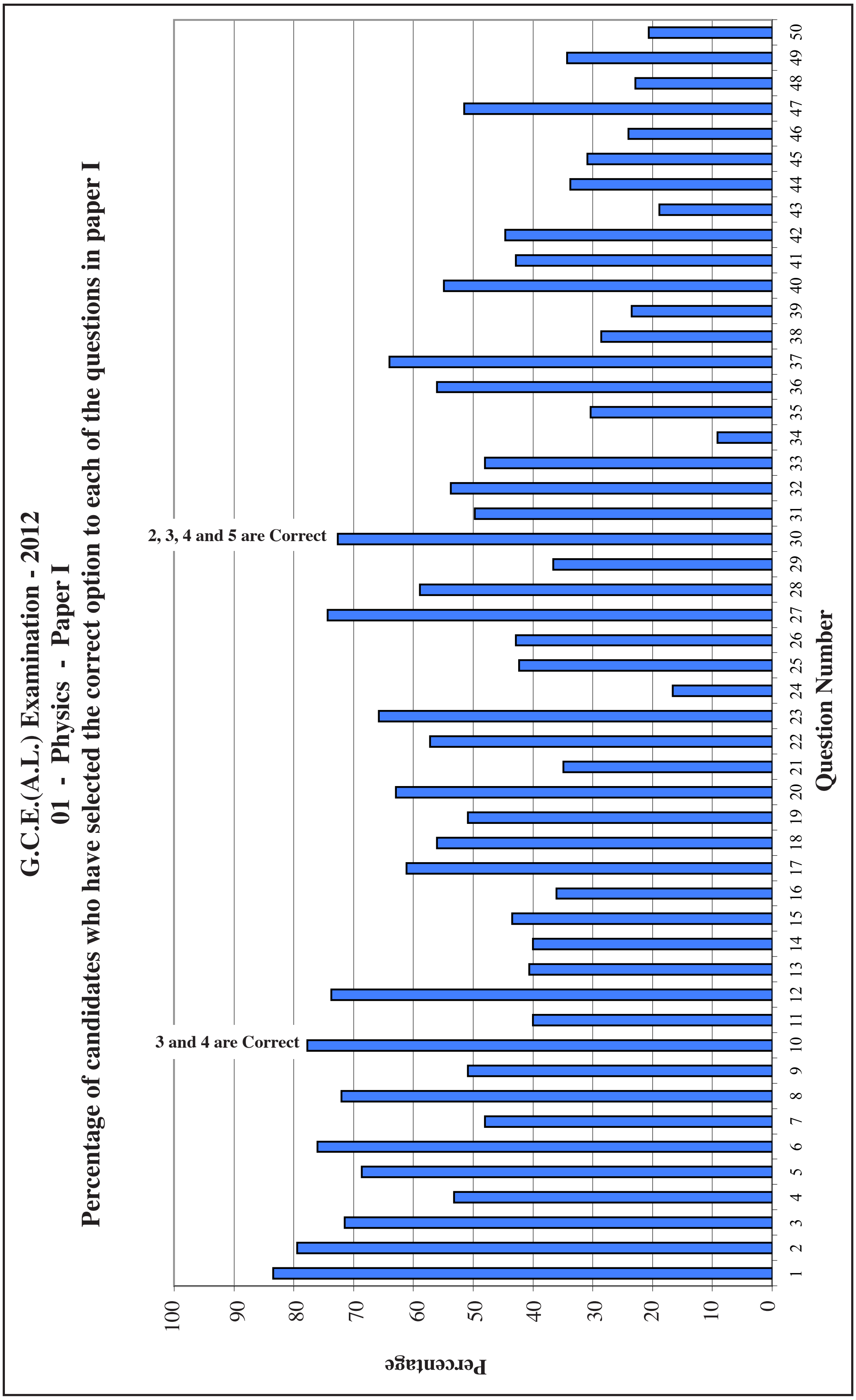
The following example illustrates how information can be retrieved from the above table:

Example : (Taking the class interval 31 - 40 for instance)

The number of candidates scoring from 31 to 40 is 10853. As a percentage it is 21.00%. The number scoring 40 marks or less than that, is 22388 and as a percentage it is 43.32%.

1.3 Analysis of Subject Achievement

1.3.1 Achievement in Paper I

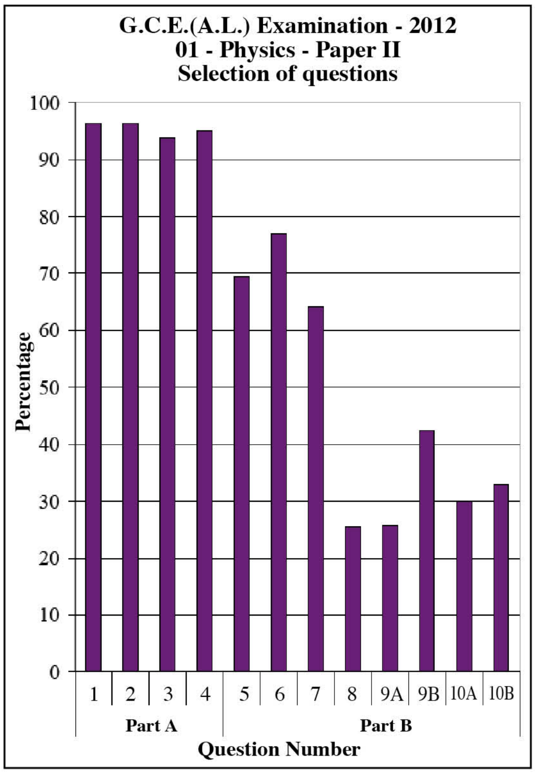


Graph 1 (Prepared using the information collected from the form RD/16/05/AL)

Retrieval of information from the above graph can be illustrated by the following example:

Eg : Highest number of candidates have correctly responded to question 1. Its percentage is 83%. Least number of candidates have correctly responded to question 34. Its percentage is 9%.

1.3.2 Selection of questions in paper II



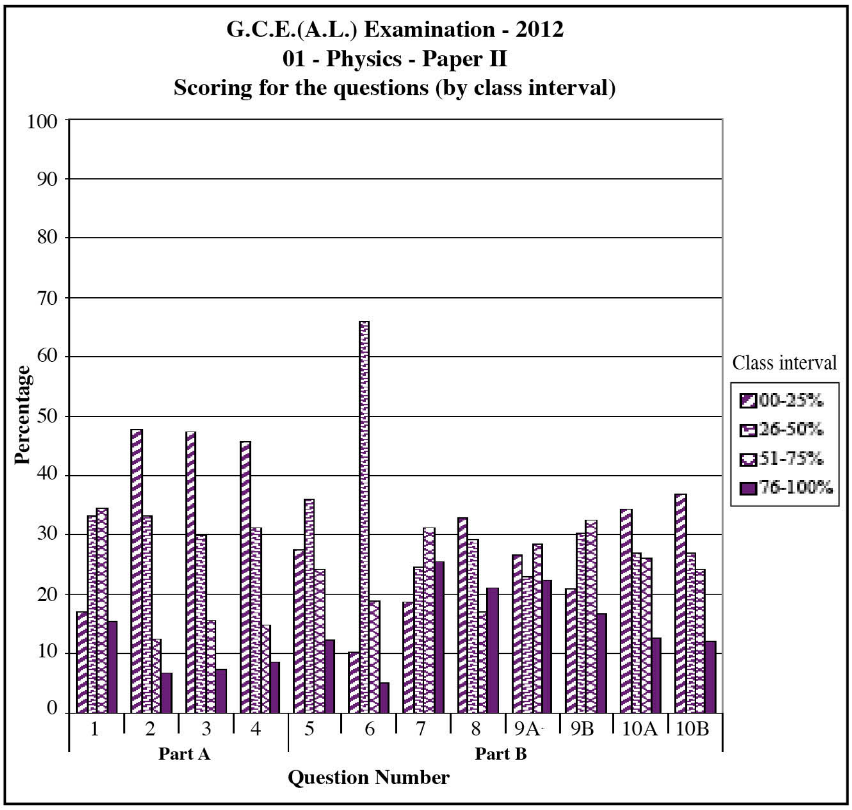
How information can be elicited from this graph is illustrated by the following example:

Eg : Though the questions 1 to 4 of this paper were compulsory, a small number has not answered even the compulsory questions. Nearly 96% of the candidates have answered the question 1. Only 94% of the candidates have answered the question 3.

Out of the questions 5 to 10 of part B, the question 6 has been selected by the majority of the candidates and the question 8 has been selected by the minority of the candidates. The percentages of candidates who selected these questions are 77% and 25% respectively.

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

1.3.3 Scoring for the questions in paper II

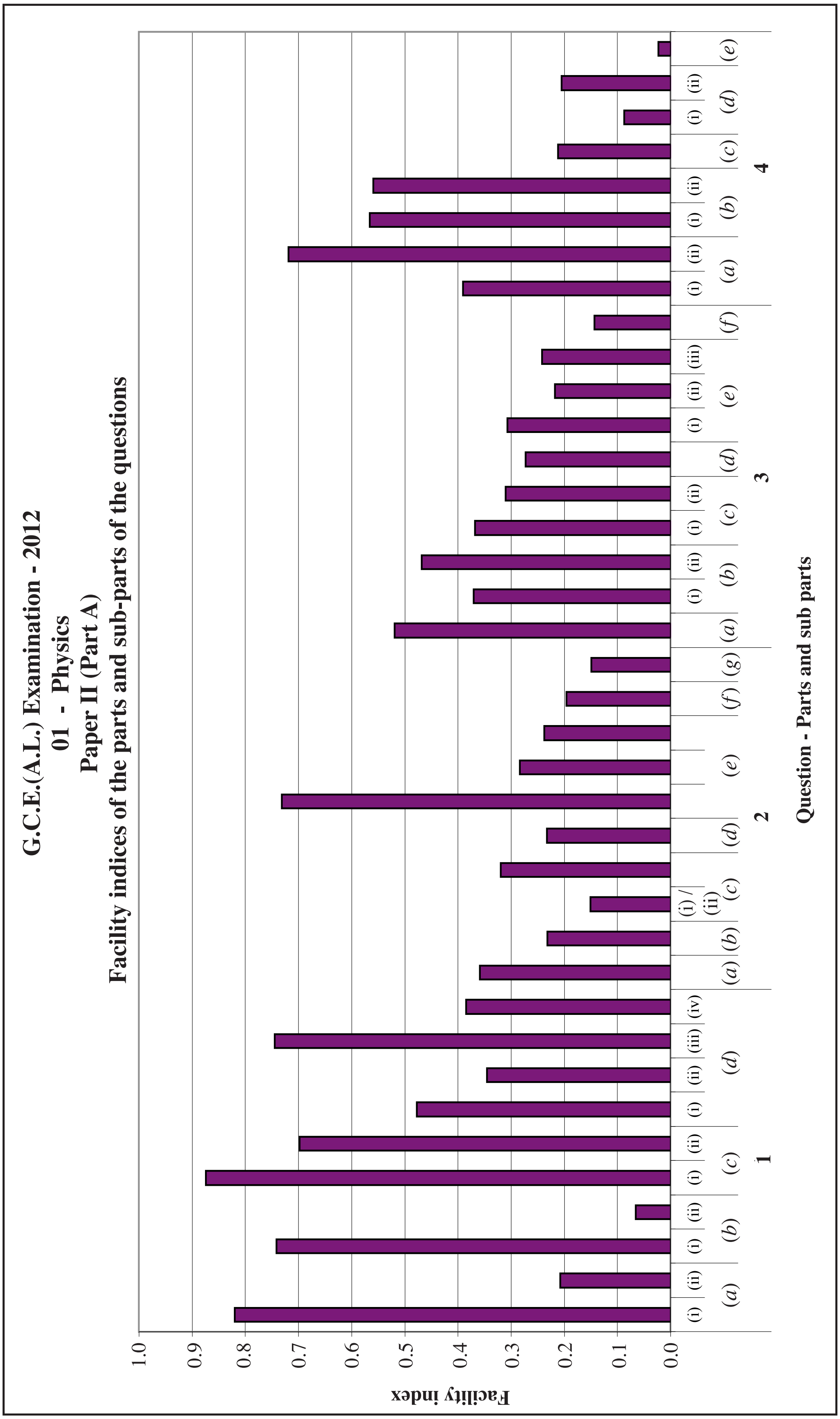


How information can be elicited from this graph is illustrated by the following example:

Eg: Marks allocated to question 1 is 10. The percentage of candidates scoring within the interval of 76% - 100% of the marks allocated, that is between 8 - 10, is 15%. The percentage of candidates scoring within the interval of 00% - 25% of the 10 marks allocated, that is from 0 to 2, is 17%.

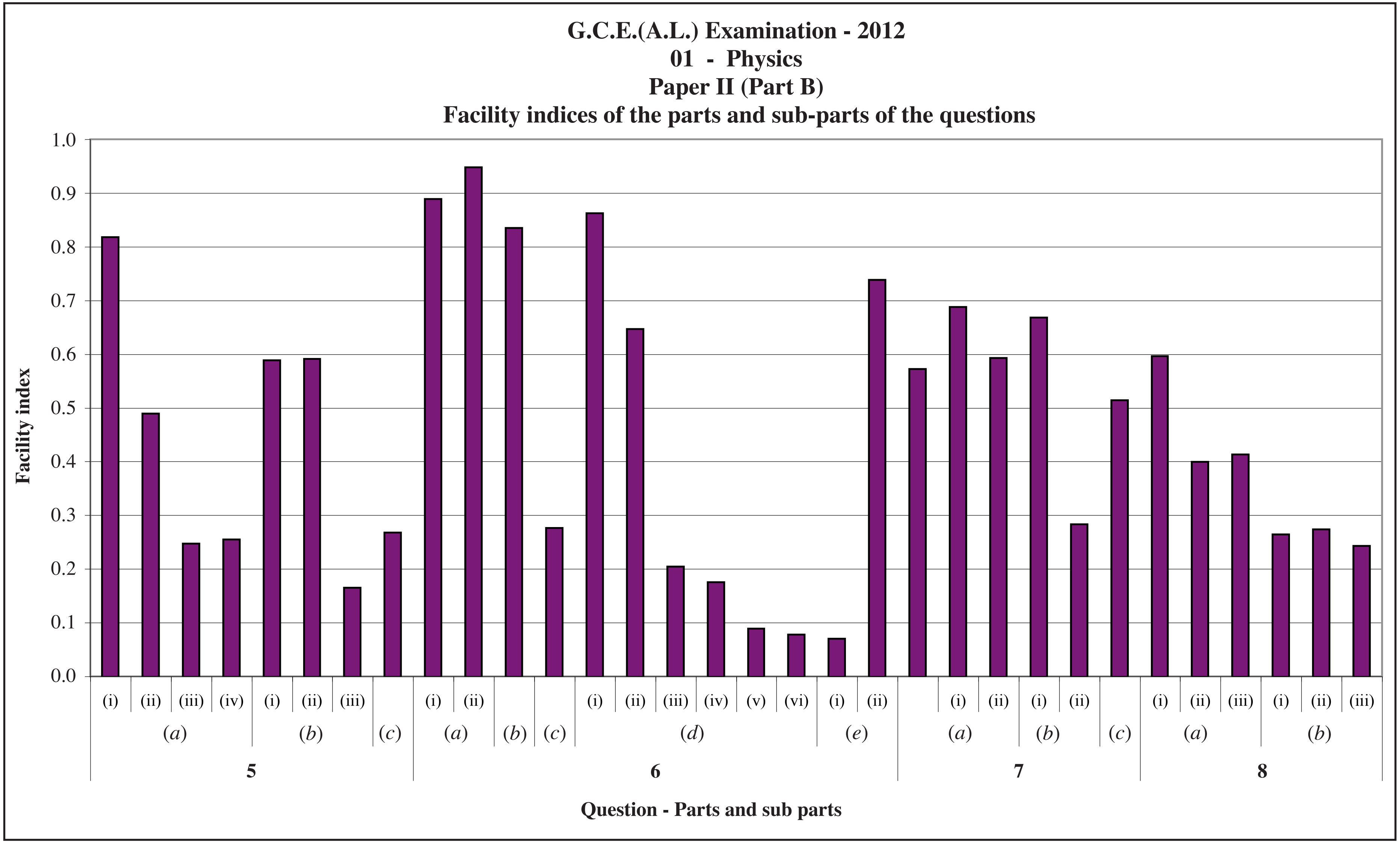
Graph 3 (Prepared using the information collected from the form RD/16/02/AL)

1.3.4 Achievement in Paper II



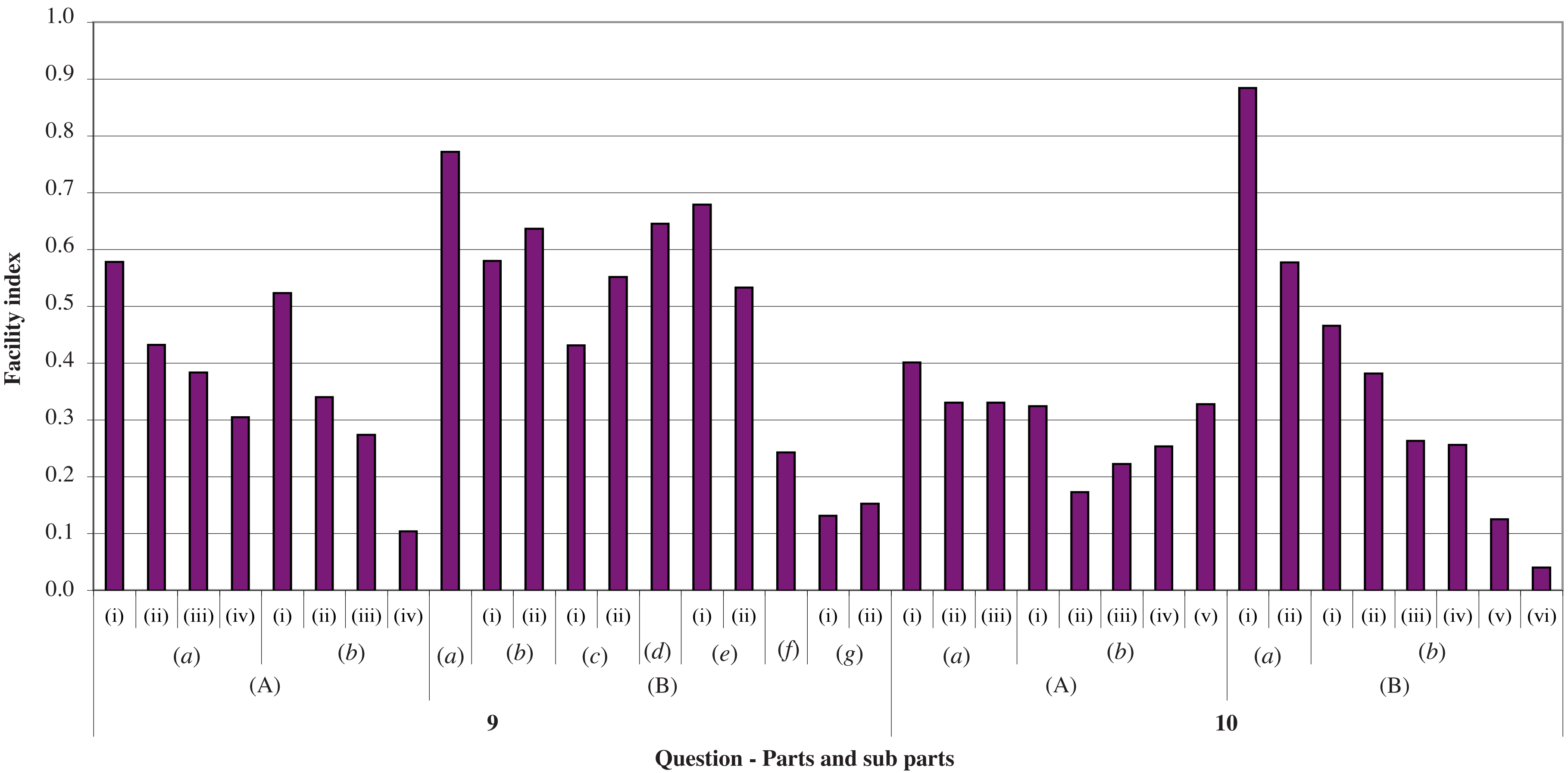
Graph 4.1 (Prepared using the information collected from the form RD/16/04/AL)

How information can be elicited from the above graph is illustrated by the following example:
Eg : The facility of part (*c*) (i) of question 1 is 87% and the facility of part (*b*) (ii) is 7%.


G.C.E.(A.L.) Examination - 2012
01 - Physics
Paper II (Part B)
Facility indices of the parts and sub-parts of the questions
Facility index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
(i) (ii) (iii) (iv) (i) (ii) (iii) (i) (ii) (i) (ii) (iii) (iv) (v) (vi) (i) (ii) (i) (ii) (i) (ii) (i) (ii) (iii) (i) (ii) (iii)
(a) (b) (c) (a) (b) (c) (d) (e) (a) (b) (c) (a) (b)
5 6 7 8
Question - Parts and sub parts

Graph 4.2

G.C.E.(A.L.) Examination - 2012
01 - Physics
Paper II (Part B)
Facility indices of the parts and sub-parts of the questions



Graph 4.3

Part II

2. Information on questions and answers

2.1 Question paper I and information on answers to paper I

2.1.1 Structure of the question paper I

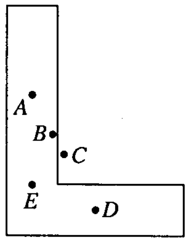
- ★ Time : 02 hours.
- ★ 50 multiple choice questions with 5 options.
- ★ All questions should be answered.
- ★ Each question carries 02 marks. Total marks : 100.

2.1.2 Paper I

1. Which of the following **does not** represent a fundamental unit in the SI system?
(1) m (2) N (3) kg (4) s (5) K

2. If the distance between two masses is doubled the gravitational force between them will decrease by a factor of
(1) 2 (2) 4 (3) 6 (4) 8 (5) 12

3. Figure shows a thin uniform L-shaped metal sheet. The centre of gravity of the sheet is most likely to be found at the point
(1) A
(2) B
(3) C
(4) D
(5) E



4. The minimum amount of work that has to be done in order to fix a light elastic string of initial length l_0 between two parallel walls separated by a distance d ($d > l_0$) with a tension T is
(1) $\frac{1}{2}T(d-l_0)$ (2) $\frac{Td}{l_0}$ (3) $T(d-l_0)$ (4) $\frac{1}{2}\frac{T}{(d-l_0)}$ (5) $\frac{1}{2}\frac{(d-l_0)^2}{T}$

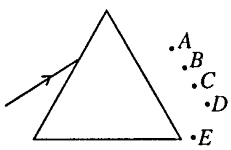
5. A vessel contains an ideal gas at 27 °C. If the temperature of the gas is increased to 127 °C, the ratio, $\frac{\text{mean kinetic energy of the gas atoms at 127 °C}}{\text{mean kinetic energy of the gas atoms at 27 °C}}$ will become
(1) $\frac{127}{27}$ (2) $\frac{16}{9}$ (3) $\frac{4}{3}$ (4) $\frac{3}{4}$ (5) $\frac{27}{127}$

6. The mass of body A is twice that of body B. The specific heat capacity of the material of body A is three times that of body B. They are supplied with equal amounts of heat. If the body A experiences a temperature change of ΔT, then body B will experience a temperature change of
(1) $\frac{\Delta T}{2}$ (2) $\frac{2}{3}\Delta T$ (3) ΔT (4) $\frac{3}{2}\Delta T$ (5) $6\Delta T$

7. Consider the following statements made about laser light.
(A) The energy of a photon in a laser beam of certain frequency is higher than the energy of a photon of the same frequency in a normal light beam.
(B) A laser beam cannot be refracted by a glass prism.
(C) All the photons in a laser beam have the same energy, the same phase, and the same direction.
Of the above statements,
(1) only (B) is true. (2) only (C) is true.
(3) only (A) and (B) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

8. A noisy workplace has a noise level of 90 dB. This was reduced to a less uncomfortable level of 70 dB. The ratio $\frac{\text{new intensity of the noise}}{\text{old intensity of the noise}}$ is equal to
(1) 0.9 (2) 0.5 (3) 0.1 (4) 0.01 (5) 0.001

9. A monochromatic ray of light is incident on a glass prism and suffers minimum deviation while going through the prism. The emergent ray most likely will go through the point
(1) A (2) B (3) C
(4) D (5) E



10. Which of the following statements made about electric field lines is **false**?
(1) Electric field lines can be either straight or curved.
(2) Electric field lines can be parallel to one another.
(3) Electric field lines can form closed loops.
(4) Electric field lines begin on positive charges and end on negative charges.
(5) Electric field lines can never intersect with one another.

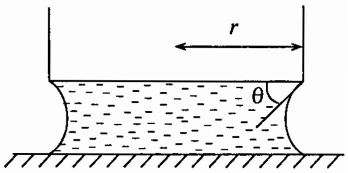
11. A spherical Gaussian surface surrounds a point charge q. The following changes were made to the system.
(A) The magnitude of the charge was tripled.
(B) The radius of the spherical Gaussian surface was doubled.
(C) The spherical Gaussian surface was changed to a surface of a cube.
(D) The charge was moved to another location inside the surface.

Of the changes mentioned above, the net electric flux through the surface is changed only in
(1) (A) (2) (A) and (B) (3) (C) and (D)
(4) (A), (B) and (D) (5) all (A), (B), (C) and (D).

12. An ideal transformer operates at V_p = 12.0 kV ac on the primary side and supplies electricity to a number of nearby houses at V_s = 240 V, ac. The turns ratio, $\dfrac{\text{number of turns in the primary}}{\text{number of turns in the secondary}}$ of the transformer is
(1) 0.02 (2) 0.2 (3) 25 (4) 50 (5) 100

13. Two copper wires have the same volume, but wire 2 is 20% longer than wire 1. The ratio, $\dfrac{\text{resistance of the wire 2}}{\text{resistance of the wire 1}}$ is
(1) 0.83 (2) 0.91 (3) 1.11 (4) 1.20 (5) 1.44

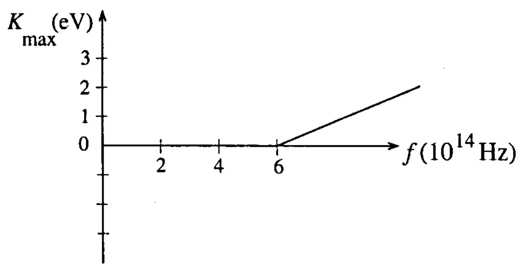
14. A water layer exists between the bottom of a cylindrical bottle and a glass plate as shown in the figure. The radius of the bottom of the bottle is r. When the bottle is raised slowly, at one instant the contact angle between water and the bottom of the bottle becomes θ. (see figure)
The magnitude of the force on the bottom of the bottle at that instant due to surface tension T of water, is



(1) $2\pi rT\sin\theta$ (2) $2\pi rT\cos\theta$ (3) $\pi r^2 T\sin\theta$ (4) $\pi r^2 T\cos\theta$ (5) $4\pi rT\sin\theta$

15. Which of the following is **not true** regarding the rate at which a body emits radiant energy?
(1) It is proportional to the surface area of the body.
(2) It is proportional to the 4th power of the absolute temperature of the body.
(3) It is proportional to the emissivity of the surface of the body.
(4) It depends on the temperature of the surrounding.
(5) It **does not** depend on the thermal capacity of the body.

16. The graph shows the variation of the maximum kinetic energy (K_{max}) of emitted photo-electrons from a metal with the frequency (f) of the incident radiation. The work function of the metal is
(1) 6.0 eV
(2) 4.0 eV
(3) 2.5 eV
(4) 2.0 eV
(5) 1.0 eV



17. A radioactive isotope of iodine, ${}^{131}_{53}\text{I}$ decays to ${}^{131}_{54}\text{Xe}$. What type of particle is emitted in this decay?
(1) α (2) β^- (3) β^+ (4) p (5) n

18. Consider the following statements made about the the information that can be obtained from dimensional analysis.
(A) Numerical values of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.
(B) Numerical signs of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.
(C) The units of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.

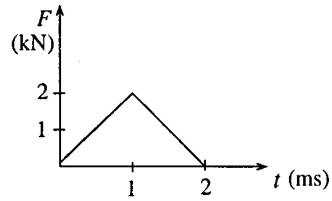
Of the above statements
(1) only (A) is true. (2) only (B) is true. (3) only (C) is true.
(4) only (B) and (C) are true. (5) all (A), (B) and (C) are true.

19. Equal masses of three liquids of densities d_1, d_2 and d_3 are added together. If the liquids mix together without causing any change, then the density of the composite liquid will be

(1) $\frac{d_1+d_2+d_3}{3}$ (2) $\frac{d_1d_2d_3}{3}$ (3) $\frac{3d_1d_2d_3}{d_1d_2+d_2d_3+d_3d_1}$

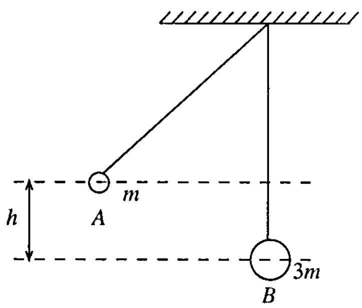
(4) $\frac{d_1d_2+d_2d_3+d_3d_1}{3}$ (5) $\frac{d_1d_2d_3}{d_1d_2+d_2d_3+d_3d_1}$

20. A ball of mass 0.5 kg which is initially at rest, is struck by a bat. The variation of the force (F) on the ball with time (t) is shown in the figure. The speed of the ball when it leaves the bat is



(1) 10 m s^{-1} (2) 8 m s^{-1} (3) 6 m s^{-1}
(4) 4 m s^{-1} (5) 2 m s^{-1}

21. Two small spheres A and B of putty of mass m and $3m$ respectively are suspended from a ceiling by means of strings of equal length. Sphere A is drawn aside so that it is raised to a height h as shown, and then released. Sphere A collides with sphere B which is at rest, and they stick together. The maximum height to which the composite body swings is

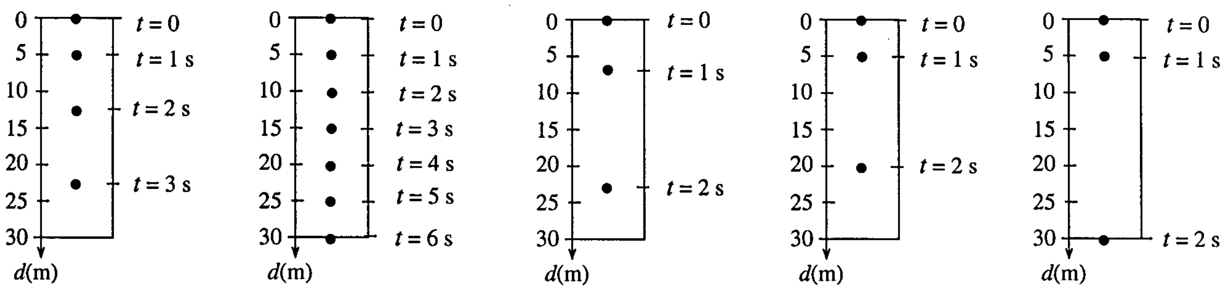


(1) $\frac{1}{16}h$ (2) $\frac{1}{8}h$ (3) $\frac{1}{4}h$
(4) $\frac{1}{3}h$ (5) $\frac{1}{2}h$

22. A car of mass m manoeuvres a circular bend of radius of curvature r in a horizontal flat road with a speed υ. If the car skids then (μ is the coefficient of friction between the road and a tyre).

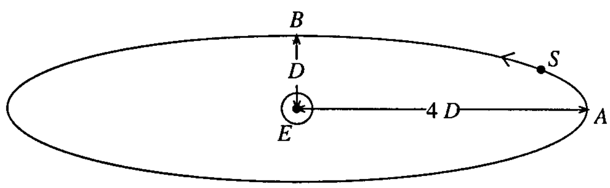
(1) $\upsilon > \sqrt{\mu r g}$ (2) $\upsilon < \sqrt{\frac{\mu r g}{4}}$ (3) $\upsilon > \sqrt{\frac{\mu r g}{m}}$ (4) $\upsilon < \sqrt{\mu r m g}$ (5) $\upsilon > \sqrt{\frac{\mu m g}{r}}$

23. Photographs of an object that starts falling freely from rest at t = 0 are taken by a camera, first at t = 0, and thereafter at the end of each second. Which of the following diagrams correctly indicates the location of the object at the end of each second? The vertical axes of the diagrams represent the distance (d) travelled by the object.



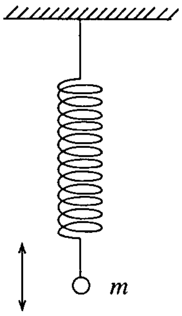
(1) (2) (3) (4) (5)

24. A satellite (S) moves in an elliptical orbit about the earth (E). If the speed of the satellite at point A is υ, then its speed at point B will be



(1) $\frac{\upsilon}{8}$ (2) $\frac{\upsilon}{4}$
(3) υ (4) 2υ
(5) 4υ

25. Consider the following statements made about a particle of mass m attached to a light spring and performing simple harmonic motion as shown in the figure.

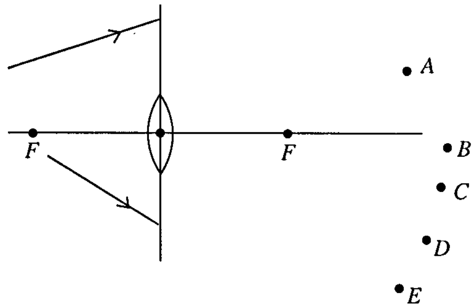


(A) The acceleration of the particle is always towards the centre of motion.
(B) The force on the particle is proportional to the square of the displacement from the centre.
(C) The period of oscillation depends on the mass of the particle.

Of the above statements,

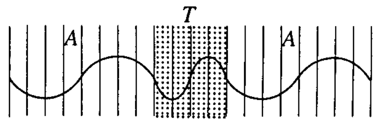
(1) only (A) is true. (2) only (C) is true.
(3) only (A) and (B) are true. (4) only (A) and (C) are true.
(5) all (A), (B) and (C) are true.

26. Consider two rays moving towards a thin converging lens as shown in the figure. After passing through the lens, the two rays are most likely to be met at the point



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

27. Figure shows the changes occurred to a waveform of a monochromatic ray of light travelling in air (A) when incident normally and transmitted through a transparent medium (T). The refractive index of the transparent medium is

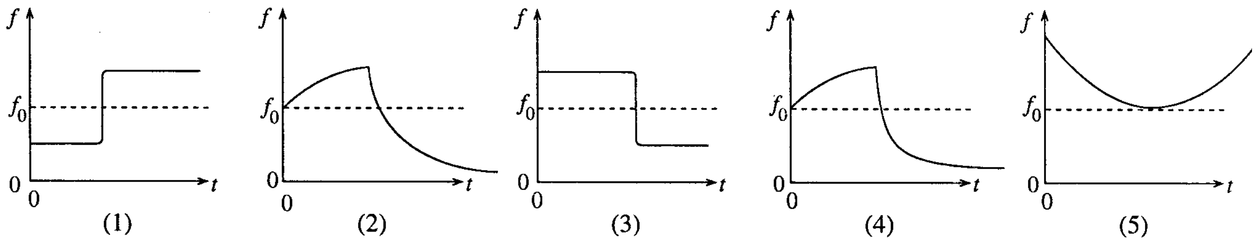


(1) 1.5 (2) 2.0 (3) 2.5
(4) 3.0 (5) 3.5

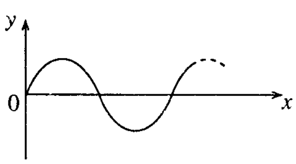
28. The human vocal tract (larynx) can be considered as a tube that is open at one end. If the length of this tube is 17 cm, the frequencies of the lowest two harmonics produced are given by (The speed of sound in air = 340 m s^{-1})

(1) 500 Hz, 1500 Hz (2) 500 Hz, 1000 Hz (3) 1000 Hz, 2000 Hz
(4) 1000 Hz, 3000 Hz (5) 1500 Hz, 2500 Hz

29. A train travelling at a constant velocity while continuously sounding its horn with a frequency f_0 moves towards an observer standing on a platform and then moves away from him. The variation of the frequency (f) of the horn as heard by the observer with time (t) is best represented by



30. The graph shows the variation of a quantity y with another quantity x. Consider the following statements.



(A) If the graph represents a wave travelling in a stretched string, along the x direction, y could be the displacement of a particle of the string in a direction perpendicular to the motion of the wave, at a given instant.
(B) If the graph represents a wave travelling in water, x could be the time and y could be the displacement of a water molecule along the direction of the wave.
(C) If the graph represents a vibration of a tuning fork, x could be the time and y could be the velocity of the tip of one prong of the fork.

Of the above statements,

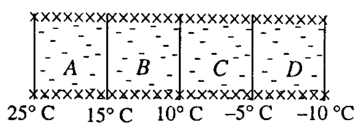
(1) only (A) is true. (2) only (C) is true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

31. A planet is observed by an astronomical telescope in normal adjustment, having an objective of focal length 14 m and an eyepiece of focal length 2 cm. Consider the following statements.
    (A) The distance between the objective and the eye piece is 1402 cm.
    (B) Angular magnification of the planet is 700.
    (C) The image of the planet is formed at the near point of the observer.
    Of the above statements
    (1) only (A) and (B) are true.
    (2) only (A) and (C) are true.
    (3) only (B) and (C) are true.
    (4) only (B) is true.
    (5) all (A), (B) and (C) are true.

32. Consider a process where air is quickly leaking out of a balloon. Which of the following is true for this process?

	ΔQ	ΔW	ΔU
(1)	+	+	+
(2)	−	−	−
(3)	0	0	0
(4)	0	−	−
(5)	0	+	−

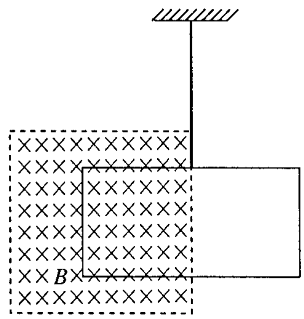
33. The figure indicates the face and interface temperatures of a lagged composite slab consisting of four materials A, B, C and D of identical thickness and surface area through which the heat transfer is steady. If k_A, k_B, k_C and k_D are the thermal conductivities of materials A, B, C and D respectively then



    (1) $k_A > k_B > k_C > k_D$
    (2) $k_A < k_B < k_C < k_D$
    (3) $k_B = k_D > k_A > k_C$
    (4) $k_B = k_D < k_A < k_C$
    (5) $k_B = k_D = k_A > k_C$

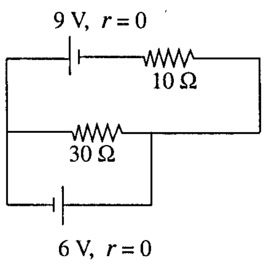
34. Consider the following statements made about the capability of a given thermometer to produce an accurate value for a temperature measurement.
    (A) In situations where quick changes of temperature with time have to be measured, the given thermometer must be a one having large variation of the thermometric property with temperature.
    (B) Thermal capacity of the thermometer must be negligible when compared to the thermal capacity of the environment of which the temperature is measured.
    (C) Thermometric property must have a linear variation with the temperature.
    Of the above statements
    (1) only (B) 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.

35. A light, conducting loop is suspended freely, and a half of the loop is inserted into a magnetic field as shown in the figure. If the magnetic field begins to increase rapidly in strength,



    (1) the loop begins to move in the direction of the magnetic field.
    (2) the loop begins to move against the direction of the magnetic field.
    (3) the loop begins to move (to the left) into the field.
    (4) the loop begins to move (to the right) out of the field.
    (5) the loop **does not** move at all.

36. Current through the 10 Ω resistor is



    (1) 0
    (2) 1.5 A
    (3) 3.0 A
    (4) 5.0 A
    (5) 6.0 A

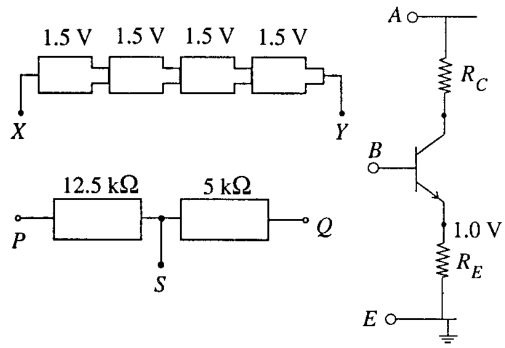
37. A metal wire has resistances R_1 and R_2 at temperatures θ_1 and θ_2 respectively. The temperature coefficient of resistivity of the metal, is given by

(1) $\dfrac{(\theta_1-\theta_2)}{(R_1-R_2)}$ (2) $\dfrac{(R_1-R_2)}{(\theta_1-\theta_2)}$ (3) $\dfrac{(R_1-R_2)}{(\theta_1-\theta_2)(R_1+R_2)}$

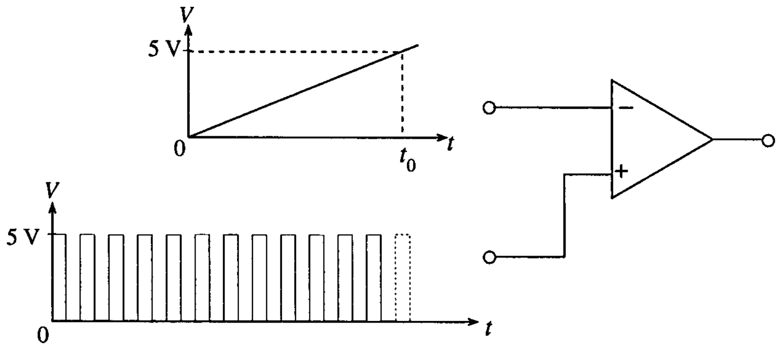
(4) $\dfrac{(R_1-R_2)}{(R_2\theta_1-R_1\theta_2)}$ (5) $\dfrac{(R_2\theta_1-R_1\theta_2)}{(R_1-R_2)}$

38. Which of the following connections will have to be made in order to operate the transistor (Si) circuit given in the figure as a common emitter amplifier?

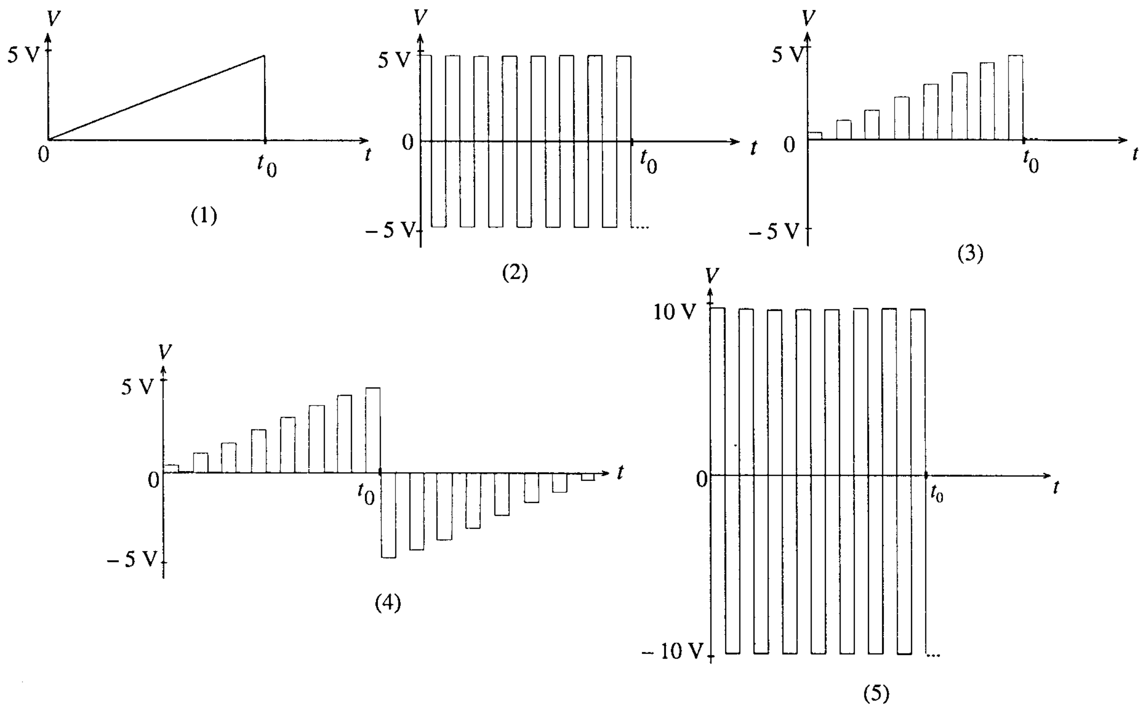
(1) *XE, YB, AP, BQ, SE*
(2) *PA, YE, XP, BS, QE*
(3) *SB, YA, AQ, BQ, SE*
(4) *XE, YB, AQ, BP, SA*
(5) *YA, XE, AP, BS, QE*



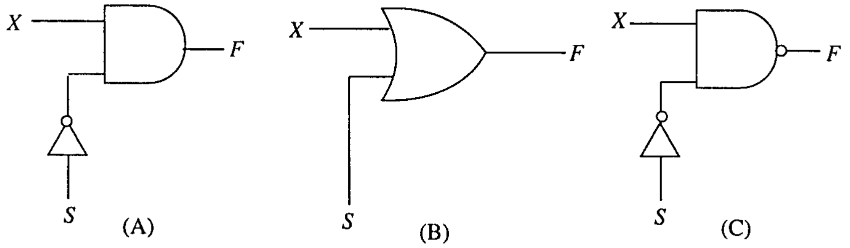
39.



The inverting input of a 741 operational amplifier operating with ±10 V power supply voltages is provided with a voltage signal which increases linearly with time (t) as shown in the figure.
The non-inverting input is provided with a rectangular voltage waveform of amplitude 5 V as shown. The output waveform of the operational amplifier is best represented by

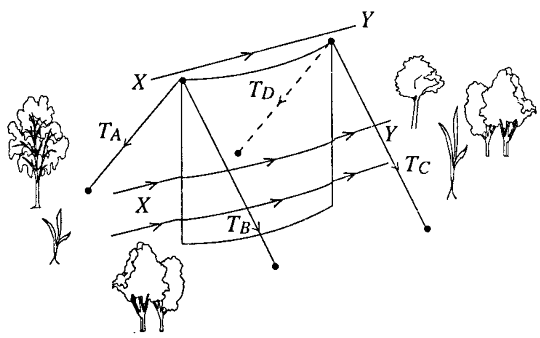


40. Which of the logic circuits shown will operate in the following manner?
When $S = 0$, output $F = X$ (value of X can be either 1 or 0)
When $S = 1$, output $F = 0$ (irrespective of the value of X)



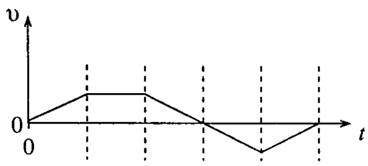
(1) (A) only. (2) (B) only (3) (C) only.
(4) (A) and (B) only (5) (B) and (C) only.

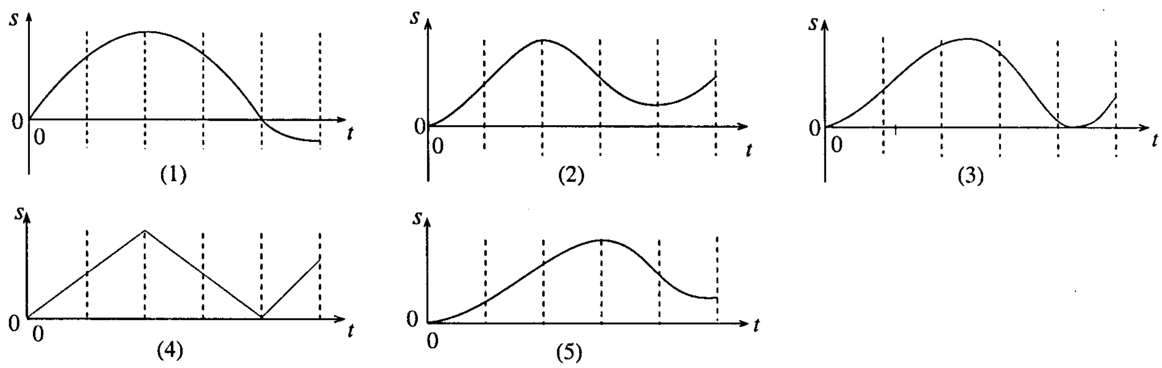
41. A large metal sheet **bent into the shape** shown in the figure is kept upright on the ground by means of four stretched ropes fixed to the ground.
Magnitudes of the tensions in all ropes, T_A, T_B, T_C, and T_D in still air are equal. When wind blows through the sheet in the direction XY



(1) $T_A < T_B$ and $T_D < T_C$
(2) $T_A > T_B$ and $T_D > T_C$
(3) $T_A = T_B$ and $T_C = T_D$
(4) $T_A > T_B$ and $T_C > T_D$
(5) $T_A < T_B$ and $T_C < T_D$

42. The variation of the velocity (υ) with time (t) of a particle is shown in the figure. The corresponding displacement (s) - time (t) curve is best represented by



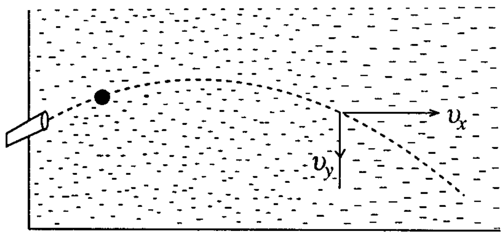


43. A grain of sand is stuck to a tyre of a vehicle at a distance r from its centre. The radius of the tyre is R. When the tyre is rotating at an angular speed of ω, the sand grain detaches suddenly from the tyre. If the air resistance is neglected, the **horizontal component** of the velocity of the grain **relative to the vehicle** immediately after detachment could have a value between

(1) 0 and $(R - r)\omega$. (2) 0 and $(r + R)\omega$. (3) 0 and $r\omega$.
(4) $-r\omega$ and $r\omega$. (5) $(R - r)\omega$ and $(r + R)\omega$.

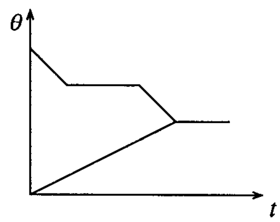
44. A lead ball of radius a is fired from a toy gun in water in a large swimming pool as shown in the figure. The densities of water and lead are ρ_w and ρ_{pb} respectively and the viscosity of water is η. If the x and y components of the velocity of the ball at a certain instant are υ_x and υ_y respectively then the magnitudes of the corresponding acceleration components at that instant would be

	x (horizontal)	y (vertical)
(1)	$\dfrac{9\eta\upsilon_x}{2a^2\rho_{pb}}$	$\left(1-\dfrac{\rho_w}{\rho_{pb}}\right)g-\dfrac{9\eta\upsilon_y}{2a^2\rho_{pb}}$
(2)	0	$\left(1-\dfrac{\rho_w}{\rho_{pb}}\right)g-\dfrac{9\eta\upsilon_y}{2a^2\rho_{pb}}$
(3)	$\dfrac{9\eta\upsilon_x}{2a^2\rho_{pb}}$	$\left(1-\dfrac{\rho_w}{\rho_{pb}}\right)g$
(4)	$\dfrac{9\eta\upsilon_x}{2a^2\rho_{pb}}$	g
(5)	0	$\left(1-\dfrac{\rho_w}{\rho_{pb}}\right)g$



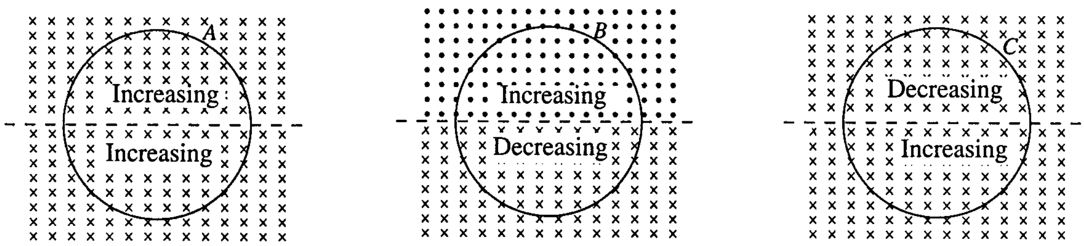
45. Water is found to condense on the outer surface of a cooled glass bottle of soft drink when kept in the atmosphere. The **total** amount of water condensed before it reaches the atmospheric temperature will **not** depend on
(1) initial temperature of the cooled bottle of soft drink.
(2) thermal capacity of the bottle of soft drink.
(3) rate of increase of temperature of the bottle of soft drink.
(4) dew point of the atmosphere.
(5) the thermal conductivity of glass.

46. Small amounts of water and ice of identical masses are placed in a thermally insulated container and allowed to come to thermal equilibrium. The variations of the temperature (θ) of water and ice are recorded with time (t) and are shown in the same graph. Which of the following conclusions can be drawn about the behaviour of water and ice from the given graph?



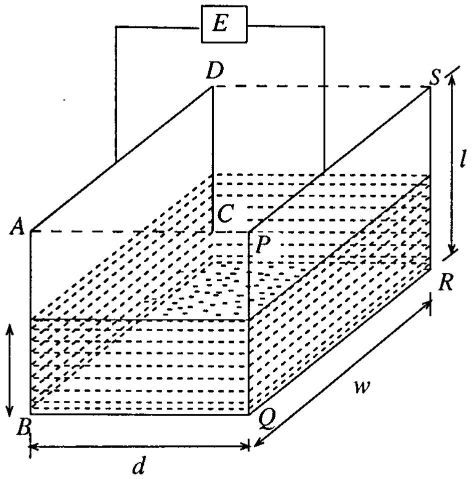
(1) Water has fully frozen and no ice has melted.
(2) Water has partly frozen and no ice has melted.
(3) Water has partly frozen and ice has fully melted.
(4) Water has fully frozen and ice has fully melted.
(5) Water has fully frozen and ice has partly melted.

47.



Three identical wire loops A, B and C are placed in uniform magnetic fields as shown in figures. Magnetic fields are either increasing or decreasing in magnitude at the same rate. If i_1, i_2, and i_3 are the magnitudes of the induced currents in loops A, B, and C respectively then
(1) $i_1 > i_2 > i_3$
(2) $i_1 < i_2 < i_3$
(3) $i_1 = i_2 = i_3$
(4) $i_1 = i_2$; $i_3 = 0$
(5) $i_1 = i_2 = i_3 = 0$

48. A fuel-gauge in a vehicle uses a parallel plate capacitor made of two rectangular metal plates to determine the height of the fuel level in the tank. Each of the metal plates ($ABCD$ and $PQRS$) has a width w and a height l. The height of the fuel level between the plates is h. (see figure) Appropriate electronic circuitry E determines the effective capacitance of the combined air and fuel capacitors. The effective capacitance of this system is given by (k = dielectric constant of fuel)

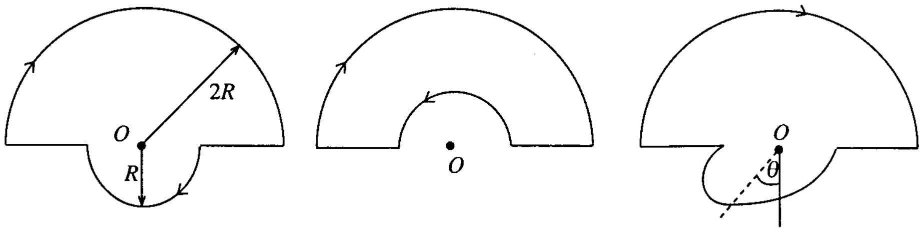


(1) $\frac{w\varepsilon_0}{d}[l+h(k-1)]$ (2) $\frac{(l-h)kh\varepsilon_0 w}{d[l+h(k-1)]}$

(3) $\frac{w\varepsilon_0}{2d}[l+h(k-1)]$ (4) $\frac{(l-h)kh\varepsilon_0 w}{2d[l+h(k-1)]}$

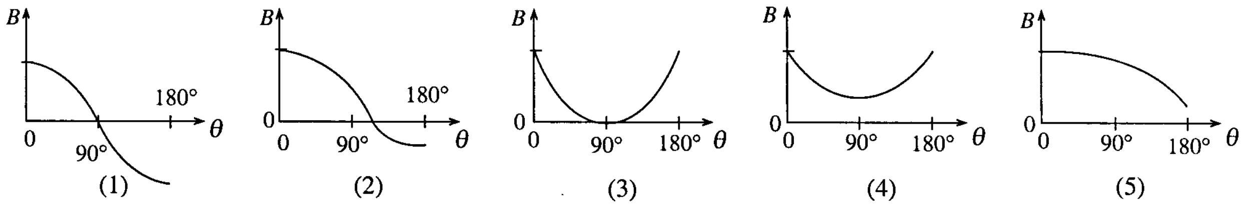
(5) $\frac{k\varepsilon_0 lw}{d}$

49.

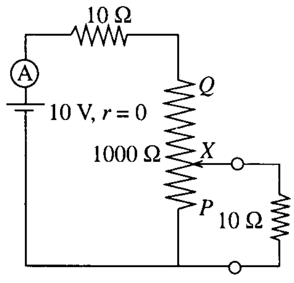


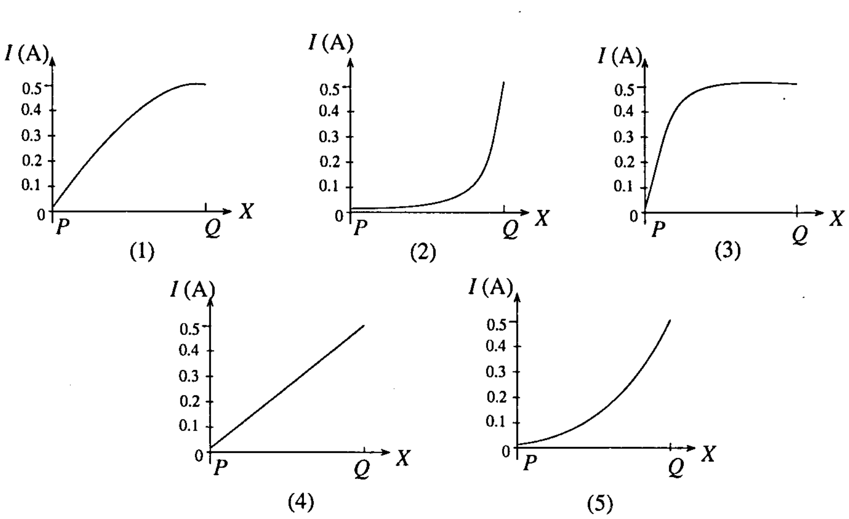
(1) (2) (3)

A current carrying wire loop in figure (1) lies in the plane of the paper and consists of two concentric semicircles of radii $2R$ and R and two radial lengths. The smaller semicircle is bent out of the plane gradually until the loop is flipped over and lies entirely on the same plane again as shown in figure (2). An intermediate situation of the system when the loop is bent through an angle θ is shown in figure (3). The variation of the component of the magnetic flux density (B) directed into the page at the center (O) of the loop with angle θ is best represented by



50. In the circuit shown PQ is a variable resistor of 1000 Ω, and the resistance between the terminals P and X varies linearly as terminal X moves from P to Q. As the terminal X moves from P to Q the variation of the ammeter reading (I) is best represented by





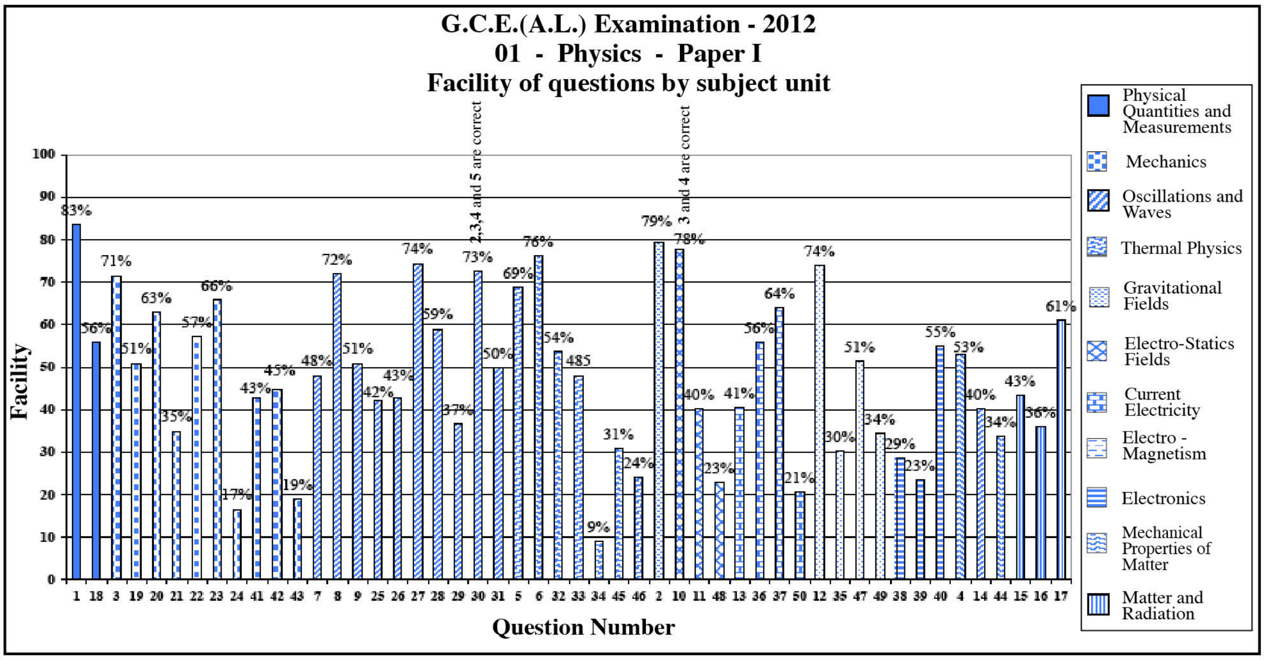
2.1.3. Expected answers and the scheme of marking

Scheme of Marking for paper I

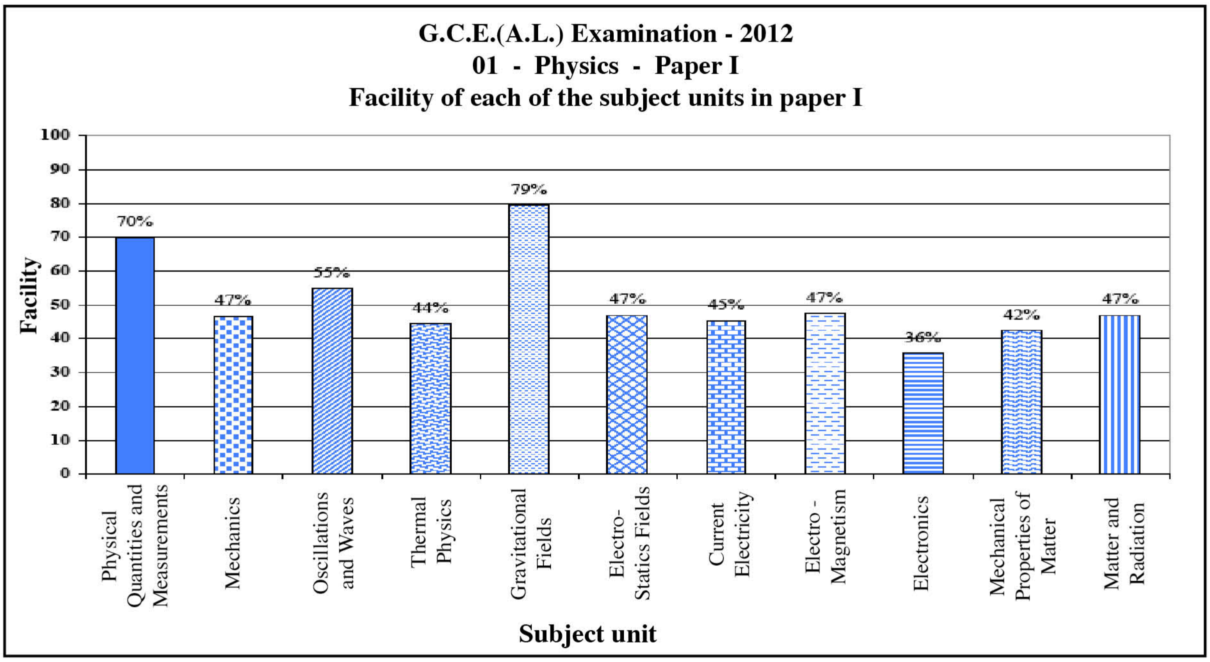
Question No.	Answer	Question No.	Answer
01.	2	26.	3
02.	2	27.	2
03.	3	28.	1
04.	1	29.	3
05.	3	30.	2, 3, 4, 5
06.	5	31.	1
07.	2	32.	5
08.	4	33.	3
09.	4	34.	1
10.	3, 4	35.	4
11.	1	36.	2
12.	4	37.	4
13.	5	38.	5
14.	1	39.	5
15.	4	40.	1
16.	3	41.	2
17.	2	42.	5
18.	3	43.	4
19.	3	44.	1
20.	4	45.	5
21.	1	46.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

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 Measurements	2	1	83%	18	56%
2. Mechanics	10	3	71%	24	17%
3. Oscillations and Waves	10	27	74%	29	37%
4. Thermal Physics	7	6	76%	34	9%
5. Gravitational Fields	1	2	79%	–	–
6. Electro-Statics Fields	3	10 (choices 3 and 4 are correct)	78%	48	23%
7. Current Electricity	4	37	64%	50	21%
8. Electro - Magnetism	4	12	74%	35	30%
9. Electronics	3	40	55%	39	23%
10. Mechanical Properties of Matter	3	4	53%	44	34%
11. Matter and Radiation	3	17	61%	16	36%



When the facility indices of each subject unit of the paper I are compared, the unit 'Gravitational Fields' has the maximum facility that of 79%. The only question, that has been set within this unit, was question 2 of the paper I, which was a simple question. This has caused the facility of the unit to be a higher value than that of other units.

Similarly, only two questions have been set within the unit 'Physical Quantities and Measurements' and since the Facility of these two questions are high, the resultant facility of this unit has taken a higher value that of 70%.

The Facility of the other units have been dispersed within an interval of 36% to 55%.

This paper contains the maximum number of questions, i.e. 10 questions, from each of the two units 'Mechanics' and 'Oscillation and waves'. These units are usually discussed at the beginning of Advanced Level classes and therefore they have shown average Facility.

The minimum facility that of 36% is shown by the unit 'Electronics'. The number of questions given within this unit is three.

2.1.5 Overall observations, conclusions and suggestions regarding the answers to the Question paper I.

More than 70% of the candidates had selected the correct choices (keys) of the questions 1, 2, 3, 6, 8, 12 and 27 of the question paper I.

Out of those, the questions 1, 2, 12 and 27 were set based on the fundamental principles. Comprehension of those fundamental principles accurately by the students has been the cause for increasing the students' achievement related to these questions.

The possibility of getting the correct answer by using diagrams or by simple calculations using a formula has increased the students' achievement for the questions 3, 6 and 8. It is necessary to pay much attention in the classroom to make students comprehend the fundamental principles accurately.

Less than 30% of the candidates have been able to select the correct choices for the questions 24, 34, 38, 39, 43, 46, 48 and 50.

Only 9% of the students have carefully read the given statements and logically selected the correct choice for the 34th question which had been set from ‘Thermometry’. The students have shown the lowest performance for this question of the paper I. Achievement of the students can be improved by practising them to answer the questions of this type, logically.

The percentage of students who have selected the correct choice for the 24th question related to the ‘Conservation of Angular Momentum’ is 17%. High achievement could be obtained by making the students practise to apply the learnt principle in practical applications.

The percentage of students who have selected the correct choice for the 43rd question related to ‘Relative Velocity’ is 19%. The correct choice could have been obtained by working out the calculation of velocity of the sand particle considering the total movement of the wheel and by paying attention to the given choices.

The questions 38 and 39 belonging to the unit ‘Electronics’ have shown low achievement levels that of 29% and 23% respectively. The low levels of students' understanding in practical applications of electronics has caused for these failures. It is necessary to guide the students, to pay their attention to practical activities in order to be successful in answering this type of questions successfully.

The percentage of students who have selected the correct option for the 50th question which is related to ‘Current Electricity’ is 21%. In this question, it is expected to find the equivalent resistance of a circuit including variable resistors and to identify the change of the current vs the linear variation of the resistance.

The percentage of students who have correctly responded to the 46th question is 24%. In this question, the conclusions must have been drawn through logical thinking. It is necessary to understand that in the first instance, the constant temperature in the graph corresponds to the state change of transforming water into ice, and in the second instance, the constant temperature in the graph which is lower than the previous value, represents the state that the temperature of the whole system exists at a constant value and then all the water in the system has been transformed into ice and all the ice is at the same temperature.

The percentage of students who have correctly responded to the 48th question is 23%. This question seems to be difficult because many students have not understood that the answer could have been obtained easily by finding the equivalent capacity of two capacitors connected in parallel.

The percentage of students who have correctly responded to the 21st question is 35%. This question is based on a number of theories. It has been difficult for the students to understand the theories required to apply in each case. The students could be guided to understand the question and apply the corresponding theories in each case appropriately.

The number of students who have correctly responded to the 16th question is 36%. This is a simple question set on fundamental theories of the last unit of the syllabus. It is necessary for the students to learn the last unit of the syllabus and try out the questions based on it.

The teachers' guidance is essential to direct students to read and understand each of the questions in paper I completely and comprehend the information provided by diagrams, graphs and statements accurately based on theories and concepts.

2.2 Paper II and information on answers

2.2.1 Structure of the paper II

Allotted time is 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. Altogether 40 marks.

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

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 for answers to paper II are based on graphs 2, 3, 4.1, 4.2 and 4.3.**

Part A - Structured Essay

1. A student has decided to measure the density of a stone with a smooth surface but having an irregular shape, at home using the following items.
   A rectangular container
   A 30 cm ruler (foot ruler) with mm scale
   Assume that he has access to the following items too.
   A household glass measuring cylinder capable of measuring liquid volumes upto nearest 5 ml.
   Electronic balance at a nearby retail shop.

(*a*) He started the experiment by determining the volume of the container using the 30 cm ruler.

(i) What are the measurements he has to take?

(1) Length [Say (x_1)]
(2) Breadth/Width [Say (x_2)]
(3) Depth OR Height [Say (x_3)] .... (01 mark)
(Measurements can be stated in any order) (All three are correct)

(ii) When an ordinary 30 cm ruler (foot ruler) is used to take the above three measurements one measurement may be less accurate,

What is that measurement?

Depth OR Height OR x_3 or any other appropriate variable

What is the reason for that?

The zero mark of the foot ruler does not coincide with its edge OR there is a gap between the zero mark and the edge of the foot ruler OR fractional error/ error of the height measurement is large .... (01 mark)
(Identification of the measurement correctly)

(*b*) He washed the stone thoroughly, dried it, and kept it inside the container as shown in figure (1). Then he filled the remaining volume of the container upto the brim with a measured amount of water using the measuring cylinder. Let the volume of water measured and added to the cylinder be *V*.

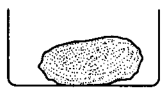


Figure (1)

(i) Write down an expression for the volume of the stone (V_0) in terms of V, x_1, x_2 and x_3.

$V_0 = x_1 x_2 x_3 - V$ .... (01 mark)

(ii) If he has the option to choose a container with the same volume but having a narrow brim as shown in figure (2), explain as to why it is advantageous to select such a container?

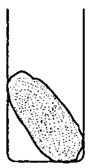


Figure (2)

Volume of water occupied above the brim level is less,
OR Error or Fractional error (or uncertainty) in V measurement,
OR in V_0, is low
.... (01 mark)

(*c*) (i) What is the other measurement that he should take in order to determine the density of the stone?

Mass of the stone OR weight (say p) ....(01 mark)

(ii) Hence write down an expression for the density (d_0) of the stone in terms of the symbols defined above.

$$d_0 = \frac{p}{x_1 x_2 x_3 - V} \quad \text{OR} \quad d_0 = \frac{p}{V_0}$$ ....(01 mark)

(No marks if weight is given as the answer under (*c*) (i), however the mark will be awarded if p is divided by 10 or g)

(*d*) Suppose you want to estimate the mass of a huge rock that is situated on a flat land as shown in figure (3), using the knowledge that you have gained from the above experiment. Assume that you have ability and provisions to construct wooden boxes of any known volume, or wooden structures of known size, and access to sufficient quantity of fine sand instead of water.

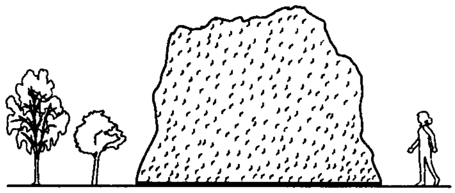


Figure (3)

(i) Write down the major steps of a method that you would suggest in order to measure the volume of the rock.

(1) Construct a rectangular structure (OR frame OR a box) enclosing the rock (a structure drawn on the above figure can be accepted)

(2) Measure its dimensions (OR volume)

(3) Fill in the remaining volume with (a measured amount of) sand

[(4) Volume of the rock = Volume enclosed by the structure - Volume of sand]

[For steps (1), (2), and (3)] ....(01 mark)

(ii) What kind of measuring device can be constructed to measure the volume of sand using the materials given under (*d*) above?

Construct a (small wooden) box with a known volume ....(01 mark)

(iii) What is the other physical quantity that is needed to estimate the mass of the rock?

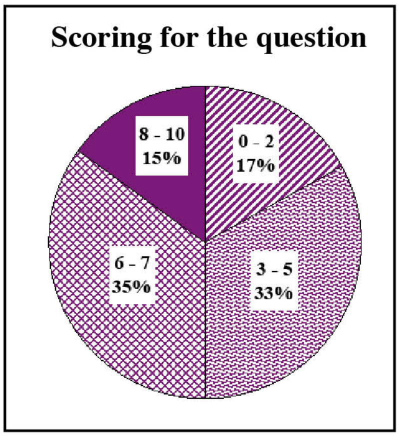
Density of the rock (material) ....(01 mark)

(iv) Suggest a method to measure the quantity mentioned in (*d*) (iii) above.

Take a small sample/piece or part of the rock material and do the experiment described above (or any other acceptable method) to find the density of the rock material

................(01 mark)

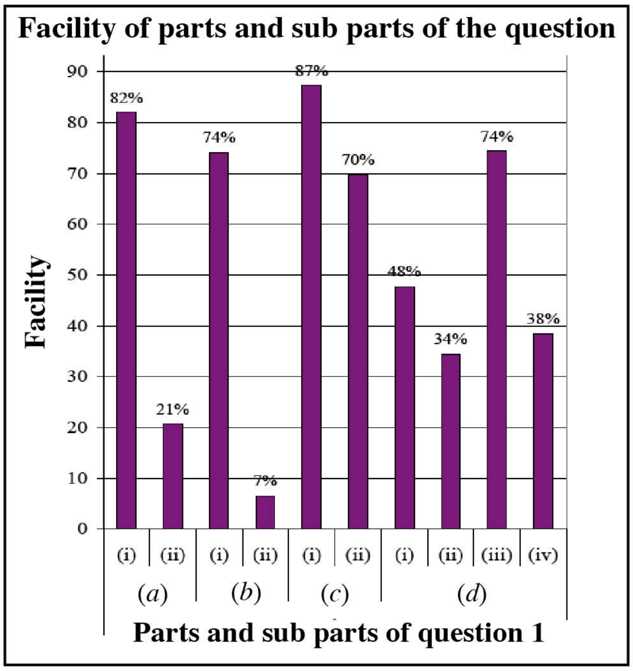
Overall observations, conclusions and suggestions based on answers to Question 1 :



Though the first question is compulsory, only 96% of the candidates have answered it. Marks allocated to this question is 10. Of the candidates who answered this question,

17% have obtained marks within the interval of 0 - 2,
33% have obtained marks within the interval of 3 - 5,
35% have obtained marks within the interval of 6 - 7,
15% have obtained marks within the interval of 8 - 10.

The percentage of candidates who obtained above 7 marks is 15% while 17% of the candidates have scored less than 3 marks.



This question contains 10 sub-parts and 5 of them have the Facility of 70% or above. The sub-part which has the least facility is (*b*) (ii) and its facility is 7%. The sub-part which has the greatest facility is (*c*) (i) and it is 87%.

The facility of sub-part (*a*) (i) is 82%. Sub-part (*c*) (i) has the maximum facility that of 87%. In these sub parts, the knowledge and application skills of basic measurements have been tested. Most of the students have been successful in this area. Reinforcement of basic concepts in students and gathering practical experiences have been the cause for this success.

The facility of the sub-part (*a*) (ii) is 21% by which the accuracy of the measurement is measured. Students' achievement has been low because they had not paid their attention on the non - coincidence of the zero point of the ruler at its end - point. It is necessary to provide the students with opportunities to observe all the related characteristics (strengths and weaknesses) of the measuring devices used in practical experiments.

The sub-part which has the minimum facility of 7% is (*b*) (i). In this instance, 93% of the candidates were unable to explain the fact that, when the area of the cross - section of a vessel decreases, the volume of the liquid that could be contained above the brim of the vessel also decreases.

The facility of the sub-part (*d*) (ii) is 34%. The students have not had a good understanding to decide the appropriate devices to be used to measure the volume of sand. It is required to direct the students to investigate not only about the measuring devices used in the laboratory but also about the other alternative apparatus used in day-to-day life.

The facility of the sub-part (*d*) (iv) is 38%. In this instance, most of the students had not understood that the sample should have been taken from the same rock.

Successful outcomes could be achieved by guiding students to find answers to the given questions by paying attention on practical experience and basic concepts.

2. You are asked to perform an experiment to verify that the value of the specific latent heat of fusion of ice is 3.3×10^5 J kg^{-1} using the method of mixtures.
Some of the items given to you are listed below.
   (1) A copper calorimeter
   (2) A beaker containing water heated to 45 °C
   (3) A block of ice

(*a*) Prepare a list of other items needed to perform this experiment.

Thermometer
Chemical balance OR Electronic balance OR Three-beam balance OR Four beam balance
(Both correct) .... (01 mark)

(Blotting papers, Stirrer with a mesh)
(No marks for 'Balance' OR 'Spring balance')

(*b*) When performing this experiment, what steps would you take to minimize the heat absorbed from the surroundings?

Start the experiment with water having a temperature higher than the room temperature by a few degrees, (OR 5 degrees) and add ice until the temperature drops below the room temperature by the same number of degrees .... (01 mark)
(Lag the Calorimeter)

(*c*) If the room temperature is 30 °C and the dew point of the atmosphere is 25 °C what values would you suggest for

(i) initial temperature of water : 34.5 °C } OR 34 °C } .... (01 mark)
(ii) minimum temperature of water : 25.5 °C } OR 26°C } (Both correct)

OR any initial temperature $\geq$ 34 °C and $<$ 35 °C
any minimum temperature $>$ 25 °C and $\leq$ 26 °C

Give reasons,

Under this condition heat absorbed form surroundings (or room) is equal to (or compensated with) the heat given out to surroundings OR
no net absorption of heat from the surroundings OR
to avoid the formation of dew .... (01 mark)
(Any one reason)

(*d*) List all the experimental measurements that you would take before adding ice.

Mass of the empty calorimeter plus stirrer
Mass of the calorimeter with stirrer plus water
Initial temperature of water
(Any order ; All correct) .... (01 mark)

(*e*) What procedures would you follow when preparing ice, adding it, and mixing with water?

Preparing : Break the ice cube into small pieces and mop (OR wipe/dry) them with a blotting (filter) paper .... (01 mark)

Adding : Add and dissolve one piece at a time
(Without splashing water) .... (01 mark)

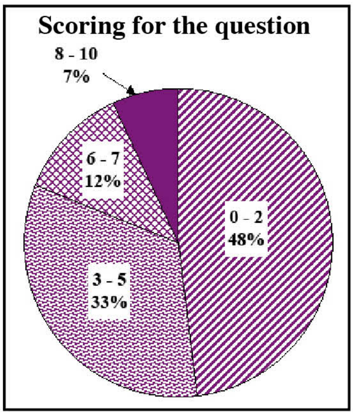
Mixing : Mix with a stirrer having a mesh OR keep the piece of ice under water all the time .... (01 mark) (*f*) **Write down the rest of the experimental measurements that you would take after adding ice.**

Minimum temperature of water / mixture / system
Mass of the calorimeter and its contents
(Both correct) .... (01 mark)

(*g*) **In this experiment the measurements that are used to determine the mass of ice have to be taken more carefully and accurately. Explain why.**

Since the latent heat of ice is large, the amount of ice needed will be small (i.e mass of ice, $M = M_2 - M_1$ is small), and therefore error (fractional error) associated with the mass measurement of ice is large .... (01 mark)

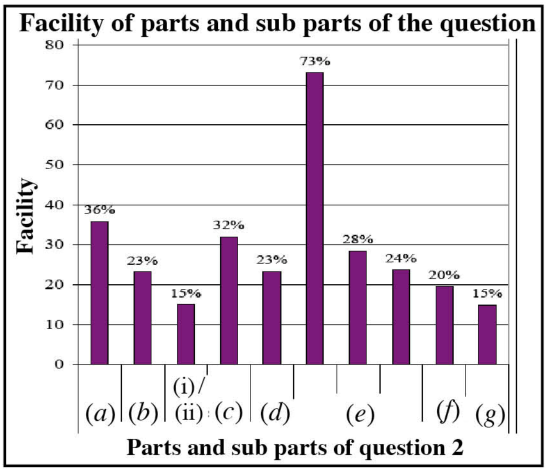
Overall observations, conclusions and suggestions based on answers to Question 2 :



Though the second question is also compulsory, It has been answered only by 96% of the candidates. Marks allocated to this question is 10. Of the candidates who answered this question,

48% have obtained marks within the interval of 0 - 2,
33% have obtained marks within the interval of 3 - 5,
12% have obtained marks within the interval of 6 - 7,
7% have obtained marks within the interval of 8 - 10.

The percentage of candidates who have scored more than 7 marks is 7% while 48% of the candidates have scored less than 3 marks.



This question contains 10 parts and sub-parts and the Facility of 7 parts and sub-parts out of them are less than 30%. The sub-part that has the maximum facility is the first sub-part of (*e*) and its facility is 73%. The sub-parts that have least Facility are (*c*) (i) / (ii) and (*g*), and the facility of each of them is 15%.

Students have scored lower marks to this question, though it has been set to find the value of the specific latent heat of fusion of ice, which is an experiment that can be easily performed in the laboratory.

Even though the questions related to this experiment had appeared in the past question papers, the minimum score in the question paper II is recorded for this question.

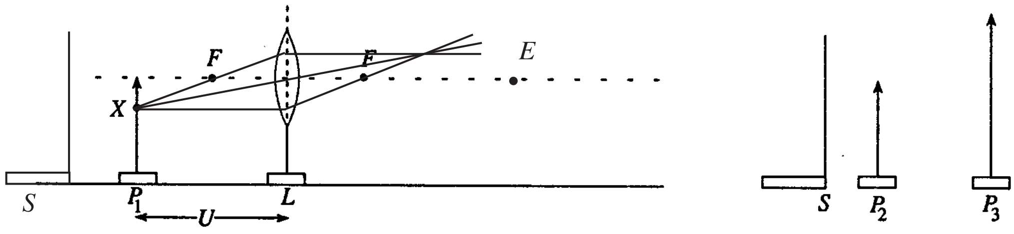
The students had answered all the sub-parts of this question, but they had lost marks because their answers were not comprehensive. The following incomplete answers were to be seen mostly:

- Writing only the term 'balance' as the equipment needed to get the measurement of mass instead of chemical / Electronic / Three-beam balance in part (*a*),
- Writing only the 'empty calorie meter' instead of the 'empty calorie meter with stirrer' in part (*d*),
- Writing only 'using the stirrer' having a mesh instead of 'keeping ice under water by using a stirrer having a mesh' in mixing ice with water in part (*e*).

Gathering experience by getting of apparatus and performing such experiments in the school laboratory by the students themselves help them keep the sequence of the experiment, fresh in their memory.

Hence, providing guidance is essential for presenting the facts related to conducting Physics practical tests / experiments and reporting findings completely and accurately. In addition, such drawbacks could be avoided by providing students with opportunities to answer the questions of this type and correcting their answers with proper feedback will definitely be more effective.

3. You are asked to verify the lens formula by plotting a suitable graph, and to determine the focal length of a convex lens. A partly assembled set-up that can be used for this purpose is shown in the following diagram. U is the object distance. You are provided with an object pin P_1, lens L, locating pins (P_2 and P_3; one short and other tall) and a white screen S.



(*a*) Considering two light rays coming from point X marked on P_1, draw a suitable ray diagram to locate the image of the object pin P_1.

At least <u>any two</u> of the rays as drawn above
(No need to draw the image, but the two rays should be extended until they meet each other; An arrow should be marked at least on one of the rays) .... (01 mark)

(*b*) (i) Draw the screen S at an appropriate place in the above diagram.

Screen placed to the left of P_1 as shown .... (01 mark)

(ii) What is the purpose of keeping S at the place where you have drawn it?

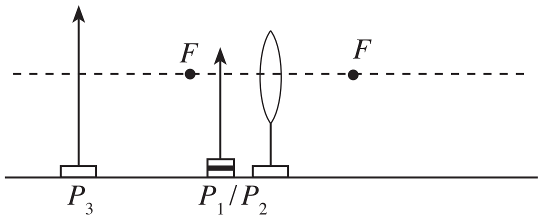
To obtain a clear view OR To avoid obstructions from other objects (for a clear view) OR To view the image of P_1 clearly OR To view only P_2 and the image of P_1
[This mark is awarded even if part (*b*) (i) is incorrect or not answered] .... (01 mark)

(*c*) (i) To determine the image distance (V) of the object pin P_1, the locating pin P_2 has to be used and you have to place your eye at a suitable position. Label this position as E in the above diagram.

Position of the eye marked (E) / the symbol of eye drawn on the principal axis and to the right of the image of P_1 OR to right of the position where the two rays intersect
.... (01 mark)

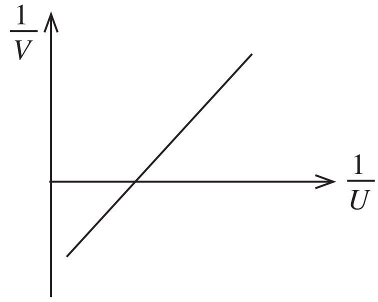
(ii) How do you make sure that the image of P_1 coincides with P_2 ?

(When the eye is moved) there should not be any relative movement between (tips of) P_2 and the image of P_1 OR P_2 and the image of P_1 move together .... (01 mark) (*d*) Suppose you want to take a few readings with virtual images too. Draw the object pin and the locating pin at appropriate places for taking such a reading, and label them as P_1, P_2 or P_3 in the following diagram (positioning them at exact locations is **not** necessary).



Placing P_1 (*or* P_2) and P_3 (taller pin) as shown
(P_1 or P_2 should be placed between F and the optical center; P_3 should be placed to the left of P_1 or P_2; the exact location of P_3 is not needed; Disregard the actual position of the tip of P_1 / P_2) ....(01 mark)

(*e*) (i) Draw a graph that you would expect to obtain on the following grid. Your graph must contain data points for real images as well as virtual images. Label the axes.



The straight line graph as shown; labeling the axes correctly.
(For both parts of the answer) ....(01 mark)

(ii) What is the expected gradient of the graph?

1 ....(01 mark)

(iii) How do you determine the focal length of the lens from the graph?

$\frac{1}{\text{intercept}}$ ....(01 mark)

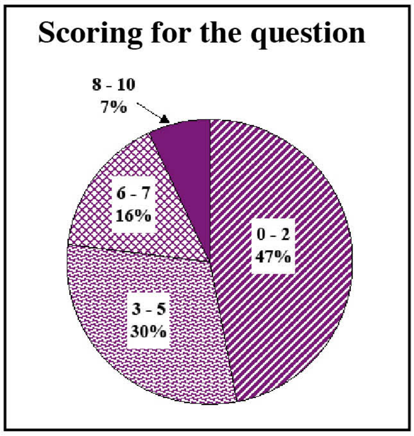
(No mark for writing the intercept)

(*f*) A student says that in the case of real images when one pair of U and V values are obtained, two data points could be plotted, on the graph. Would you agree with this? Give reasons for your answer.

Yes

(For real images) U and V values can be interchanged with each other OR When a certain V value becomes U, the corresponding U value will become V OR Due to the principle of reversibility of light ....(01 mark)

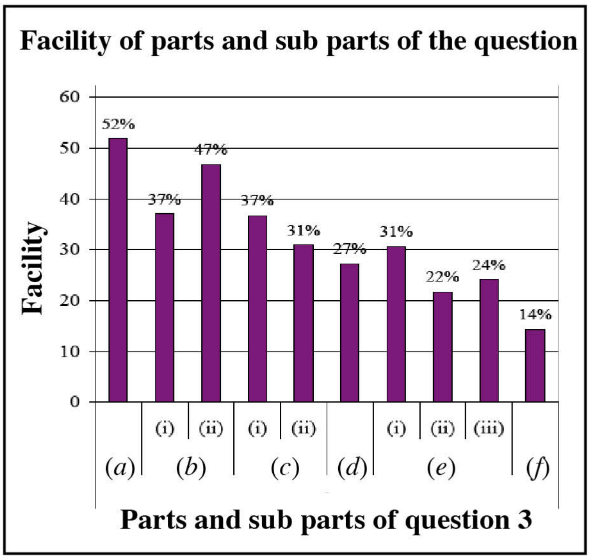
Overall observations, conclusions and suggestions based on answers to Question 3 :



Though the third question also is compulsory, only 94% of the candidates had answered it. The total marks allotted to this question is 10. Of the candidates who answered this question,

47% have obtained marks within the interval of 0 - 2,
30% have obtained marks within the interval of 3 - 5,
16% have obtained marks within the interval of 6 - 7,
7% have obtained marks within the interval of 8 - 10.

The percentage of candidates who obtained more than 7 marks is 7% while 47% of the candidates have scored less than 3 marks.



This question contains 10 sub-parts and the Facility of 4 sub-parts out of them are less than 30%. The sub-part that has the maximum facility is (*a*) and its facility is 52%. The sub-part that has the least facility is (*f*), and its facility is 14%.

This question is related to the functions of the lenses which comes within the unit 'Optics' and the Facility of all the parts and sub-parts of this question vary at a lower achievement level of 14% to 52%.

The facility of the sub-part (*b*) (i) is 37%. Most of the students had not understood that the screen *S* is kept in order to have a clear visionary but not for getting the image on it. This fact must be considered in conducting experiments / laboratory tests related to optics.

The facility of the sub-part (*c*) (i) is also 37%. Only 37% of the students who had correctly understood that the eye had to be moved along the major axis had succeeded in answering the sub-part (*c*) (i). The facility of the sub-part (*c*) (ii) is 31%. Only 31% of the candidates were able to state how the coincidence case could be identified. The facility of the part (*d*) is 27%. Out of the candidates, 73% has failed to select the appropriate pin from the given pins, depending on the size of the image. It is necessary to provide the students with opportunities to understand such facts through practical experiments. The Facility of sub-parts (i), (ii) and (iii) of part (*e*) are 31%, 22% and 24% respectively. Most of the students have failed to identify the relevant variable, to arrange the lens formula appropriately, to obtain the sketch of the graph and its gradient in an experiment. It is necessary to draw the graph as a continuous straight line using all data. Part (*f*) has the least facility and its facility is 14%. The knowledge of the students regarding the reversibility of the light is insufficient. Therefore, it is suitable to pay more attention to it.

It is necessary to practise not only conducting practical experiments but also drawing related graphs and doing related computations in the classroom.

4. Figure (1) shows an incomplete diagram of a potentiometer arrangement used for measuring the internal resistance of a cell.

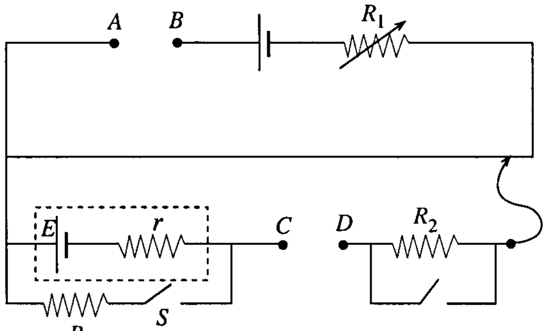


Figure (1)

(*a*) In addition to the items corresponding to the symbols shown in figure (1), if you are provided with the items shown in figure (2) to perform this experiment,

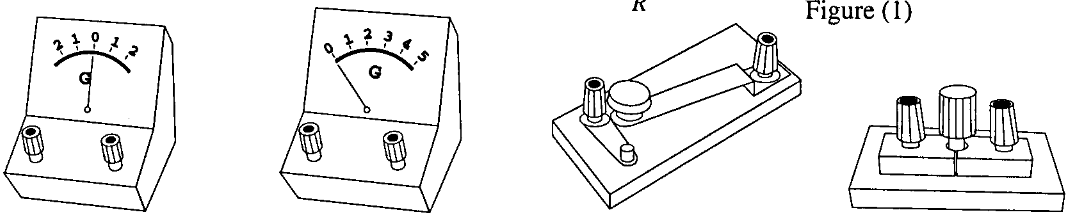


Figure (2)

Item (1) Item (2) Item (3) Item (4)

(i) which item would you connect between *AB*?

Item 4 ....(01 mark)

(ii) which item would you connect between *CD*?

Item 1 ....(01 mark)

(If the connections of the appropriate items to the circuit have been drawn, they are considered as correct.)

(*b*) In this experiment, after the apparatus is setup properly, **two** balance lengths must be taken. What are they?

(i) Balance length with *S* open
OR balance length when current is not flowing from cell *E* ....(01 mark)

(ii) Balance length with *S* closed
OR balance length when current is flowing from cell *E* ....(01 mark)

(*c*) If the balance lengths taken by a student were 90 cm and 80 cm, calculate *r*. (The value of *R* was 5 Ω during these measurements).

$E = kl_1$ OR $E \propto l_1$ or 90 ....(01 mark)

$\frac{ER}{R+r} = kl_2$ OR $\frac{ER}{R+r} \propto l_2$ or 80 ....(01 mark)

[OR $\frac{E}{ER/(R+r)} = \frac{90}{80}$ ....02 mark]

$$r = R\,\frac{(l_1 - l_2)}{l_2}$$

$$= 5\,\frac{(90-80)}{80}$$

$= 0.625\ \Omega$ ....(01 mark) (*d*) For maximum accuracy, the potentiometer must be adjusted so as to give largest possible values for the balance lengths.

(i) Which of the **two** balance lengths mentioned in (*b*) above must be used for this adjustment? Give reasons for your answer.

The balance length with S open
This is the larger balance length
(For both correct) .... (01 mark)

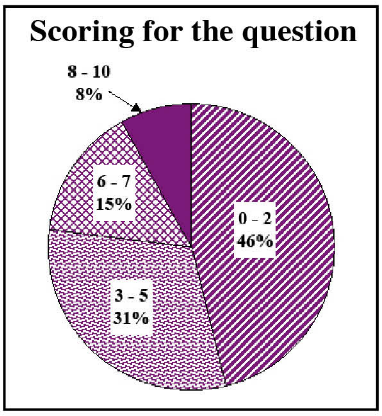
(ii) With what item do you perform this adjustment?

R_1 .... (01 mark)

(*e*) If an R value much larger than 5 Ω, is used in the circuit when taking measurements under (*b*) above, would you expect a more accurate or less accurate value for r? Give reasons for your answer.

A less accurate value,
Because the error (or fractional error) in the $(l_1 - l_2)$ measurement is large
OR the measurements of l_1 and l_2 will be almost the same
OR the measurement of l_1 will be approximately equal to that of l_2
OR the difference between the measurements of l_1 and l_2 will be small.
(For any reason) .... (01 mark)

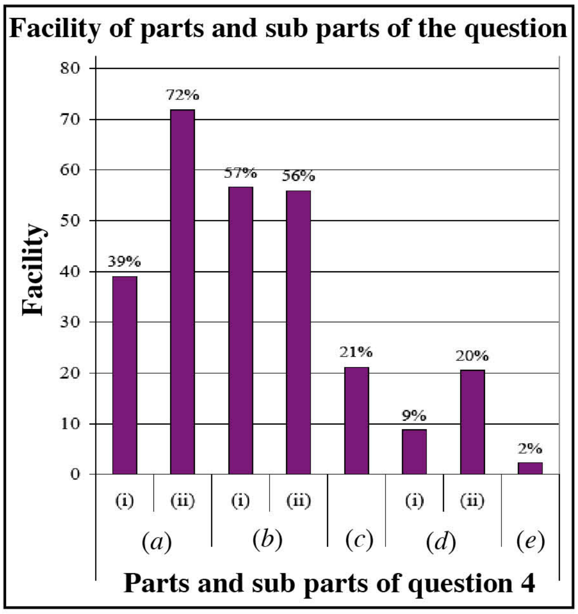
Overall observations, conclusions and suggestions based on answers to Question 4 :



Though the fourth question is also compulsory, only 95% of the candidates have answered it. Marks allocated to this question is 10. Of the candidates who answered this question,

46% have obtained marks within the interval of 0 - 2,
31% have obtained marks within the interval of 3 - 5,
15% have obtained marks within the interval of 6 - 7,
8% have obtained marks within the interval of 8 - 10.

The percentage of candidates who obtained marks more than 7 is 8% while 46% of the candidates have scored less than 3 marks.



This question contains 8 sub-parts and the Facility of 4 sub-parts out of them are less than 30%. The sub-part that has the maximum facility is (*a*) (ii) and its facility is 72%. The sub-part that has the least facility is (*e*), and its facility is 2%.

The facility of sub-part (*a*) (i) is 39%. The understanding of students about the switches used in circuits is insufficient. It is suitable to make the students aware of different types of switches used in different circuits.

The facility of part (*c*) is 21%. Total marks allotted to this part has not been scored because the candidates have not calculated the value of *r* using basic equations related to the potentiometer. Further more, the final answer should not have been rounded off because its value has come in three decimal places.

The facility of the sub-part (*d*) (i) is 9% while the facility of the sub-part (*d*) (ii) is 20%. To increase the accuracy of the reading, the balance length must have been increased. For this purpose, the variable resistant R_1 has to be adjusted such that it satisfies the instance of getting the larger balance length. It is necessary to make the students understand about such needs in practical experiments.

The facility of part (*e*) is 2%. About 98% of the students have not developed the ability of explaining the changes that take place when a particular change in the circuit is done. It is necessary to train the students to explain such instances logically.

PART B – Eassy

5. In this question, you will investigate a few basic movements of a robotic arm shown in figure (1).

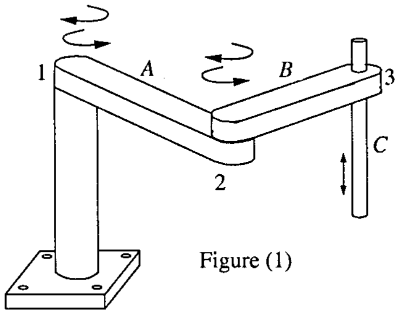


Figure (1)

The arm segments A and B of the robot have the ability to rotate in either direction around joints 1 and 2 in horizontal planes. Joint 3 allows segment C to move up and down. All three joints are operated by electric motors. Assume that only one movement around or across a joint is allowed at a given time and that there is no friction in any of the joints.

(*a*) First consider an upward motion of segment C. This motion is described by the velocity (υ) - time (t) graph in figure (2). Mass of segment C is 0.1 kg.

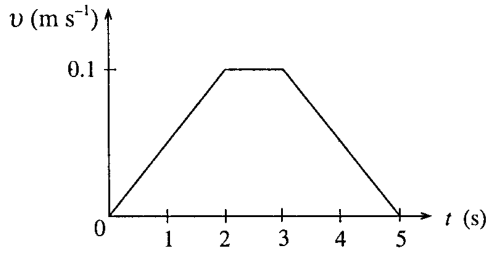


Figure (2)

(i) Calculate the acceleration of segment C during the first 2 seconds.

(ii) The forces acting on C are its weight, and the force applied by the motor for the motion of C. Calculate the force applied by the motor during the first 2 seconds.

(iii) What are the magnitude and direction of the force applied by the motor on C during the last 2 seconds of motion?

(iv) Suppose the magnitude of the maximum force the motor can exert on C is 1.2 N. If starting from rest, C moves up under this maximum force for 0.5 s, how far will it move?

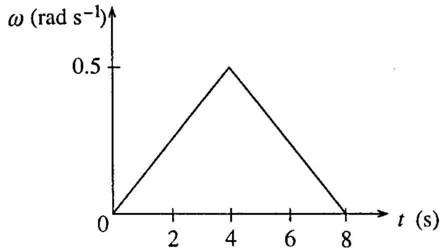


Figure (3)

(*b*) Next consider a rotation of segment B (together with segment C) occuring around joint 2. The angular velocity (ω) - time (t) graph in figure (3) shows this rotation. Assume that segment A is held fixed during this rotational motion.

The moment of inertia of the combined system of segments B and C around the axis of joint 2 is 0.01 kg m^2.

(i) Calculate the torque applied by the motor on B during the first 4 seconds of motion shown in figure (3).

(ii) Calculate the angular displacement of B during the 8 s period shown in figure (3).

(iii) If the magnitude of the maximum torque that can be applied by the motor is 0.002 N m, what is the **minimum** time that will take for B to start from rest and come to rest again after an angular displacement of 3.2 radians?

(*c*) Now if segment A is allowed to rotate freely around joint 1, what would be the direction of rotation of segment A, when segment B, starting from rest, rotates clockwise around joint 2? Give reasons for your answer.

5. (*a*) (i) Acceleration $= \dfrac{0.1}{2}$

$= 0.05 \text{ m s}^{-2}$ ....(01 mark)

(ii) Using $F = ma,$ ....(01 mark)

$F - 0.1 \times 10 = 0.1 \times 0.05$ ....(01 mark)

$F = 1.005 \text{ N}$ ....(01 mark)

(iii) Acceleration $= -0.05 \text{ m s}^{-2}$

$F - 0.1 \times 10 = -0.1 \times 0.05$

$F = 0.995 \text{ N}$ ....(01 mark)

Direction is upward. (OR an arrow pointing upwards) ....(01 mark)

(iv) Using $F = ma$,

$$1.2 - 0.1 \times 10 = 0.1\,a$$ ....(01 mark)

$$a = 2\,\mathrm{m\,s^{-2}}$$

Using $s = \frac{1}{2}at^2$,

$$s = \frac{1}{2} \times 2 \times (0.5)^2$$

$$= 0.25\,\mathrm{m}$$ ....(01 mark)

(*b*) (i) Angular acceleration $= \frac{0.5}{4}$ ....(01 mark)

$$= 0.125\,\mathrm{rad\,s^{-2}}$$

Torque $= 0.01 \times 0.125$

$$= 0.00125\,\mathrm{N\,m}$$ ....(01 mark)

(ii) Angle of rotation $= \frac{1}{2} \times 0.5 \times 8$ (OR $2 \times \frac{1}{2} \times 0.125 \times 4^2$)

$$= 2\,\mathrm{rad}$$ ....(01 mark)

(iii) Angular acceleration under maximum torque $= \frac{0.002}{0.01}$

$$= 0.2\,\mathrm{rad\,s^{-2}}$$

To perform the required operation at a minimum time, arm B would have to be rotated at an angular acceleration of $0.2\,\mathrm{rad\,s^{-2}}$ during the first half of the time, and at a deceleration of $0.2\,\mathrm{rad\,s^{-2}}$ during the second half.

(Identification of this as the minimum time) ....(01 mark)

$$\Delta\theta = 2 \times \frac{1}{2}\alpha\left(\frac{t}{2}\right)^2$$

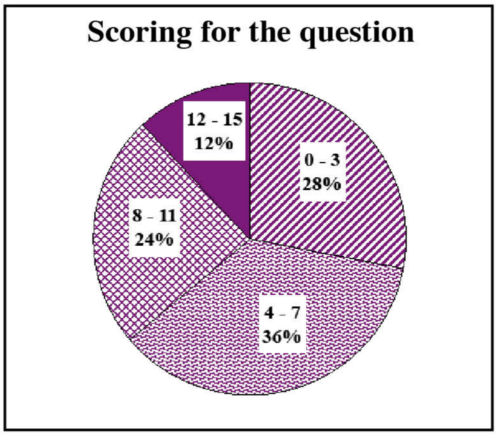
$$t = \sqrt{\frac{4\Delta\theta}{\alpha}}$$

$$t = \sqrt{\frac{4 \times 3.2}{0.2}} \quad \text{OR} \quad t_1 = \sqrt{\frac{2 \times 1.6}{0.2}} \quad (\text{where } t_1 = t/2)$$ ....(01 mark)

$$t = 8\,\mathrm{s}$$ ....(01 mark)

(*c*) The arm will rotate anti-clock wise. This is due to conservation of angular momentum.
(For direction and reason both) ....(01 mark)

Overall observations, conclusions and suggestions based on answers to Question 5 :



Only 69% of the candidates have selected this question. This question carries 15 marks. Of the candidates who answered this question,

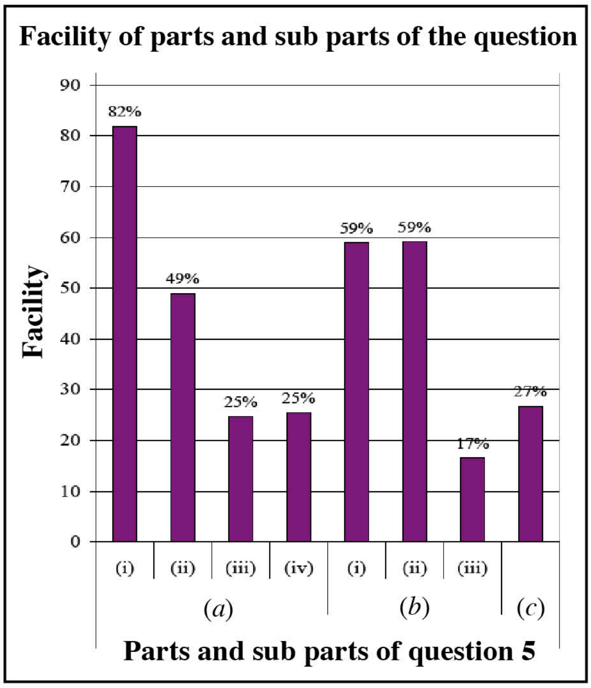
28% have obtained marks within the interval of 0 - 3,

36% have obtained marks within the interval of 4 - 7,

24% have obtained marks within the interval of 8 - 11,

12% have obtained marks within the interval of 12 - 15.

The percentage of candidates who have scored more than 11 marks is 12% while 28% of the candidates have scored less than 4 marks.



This question has eight parts and sub-parts. The Facility of four parts / sub-parts out of them are less than 30%. The sub-part that has the maximum facility is (*a*) (i) and its facility is 82%. The sub-part that has the minimum facility is (*b*) (iii) and its facility is 17%.

This question has been selected by 69% of the candidates and it is based on applying the theories related to the Newton's Laws of Motion, Graphs of motion and Angular motion in a practical situation that come under the unit 'Mechanics'.

The Facility of the sub-parts (*a*) (iii) and (*a*) (iv) of this question are 25% each. Most of the students have been unable to find the magnitude and the direction of the force accurately because they had not applied the negative sign in 'a' in the equation '$F = ma$' which was supposed to be used for the motion in retardation in sub-part (*a*) (iii). The students must be aware to be careful in using the sign convention (+ve and -ve signs) while substituting the values in an equation consists of vectors.

The facility of the sub-part (*b*) (iii) is 17%. Students had not been able to obtain the correct answer because they have not identified the instance that has the minimum time period.

The facility of the part (*c*) is 27%. The question has been difficult to answer because the students had not understood that the practical event takes place according to the Law of Conservation of Angular Momentum. It is useful to be thorough of the theories learnt using practical experiences.

6. Read the following passage and answer the questions given below.

The Doppler effect for sound waves depends on three velocities, namely the velocities of sound, the source, and the observer with respect to the air. Normally air is considered to be stationary relative to the ground and therefore these velocities can be measured relative to the ground.

However, this is not the situation with regard to light waves. Light as well as other electromagnetic waves require no medium, and they are capable of travelling even through a vacuum. The Doppler effect for light waves depends on two velocities, namely the velocity of light (c) and the relative velocity (υ) between the source and the observer, as measured from the reference frame of either source or the observer.

If a certain light source is at rest relative to us, we would detect light from it with the same frequency (f_0) as that of the source, and it is known as the proper frequency. If it is moving away from us with a speed υ ($\upsilon << c$), then the light we detect has a frequency f that is shifted from f_0 due to the Doppler effect and f is given by the following formula.

$$f = f_0(1-\beta) \quad \text{where} \quad \beta = \frac{\upsilon}{c}$$

However, measurements involving light are usually made in wavelengths rather than frequencies, and the above formula can be rewritten in terms of wavelengths in the following form.

$$\upsilon = \frac{\Delta\lambda}{\lambda_0}c \quad \text{where} \quad \Delta\lambda = \lambda - \lambda_0$$

The quantity $\Delta\lambda$ is called the Doppler shift.

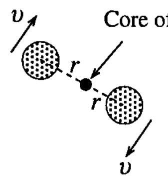


Figure (1)

If the light source is moving away from us, λ is longer than λ_0, $\Delta\lambda$ is positive, and the Doppler shift is called a red shift. If the light source is moving toward us, then λ is shorter than λ_0, $\Delta\lambda$ is negative, and the Doppler shift is called a blue shift.

Using astronomical observations of stars, galaxies and other sources of light, scientists can determine how fast the sources are moving, either directly away from us or directly towards us by measuring the Doppler shift of the light that reaches us.

Two regions of interstellar gas orbiting the core of a galaxy known as M87 at a radius r = 100 light years is shown in figure (1). One region is moving towards us with a speed υ and and the other region is moving away from us with the same speed. Figure (2) shows the variation of intensity (I) with wavelength (λ) of light reaching us from those two regions.

The gas is under the influence of the gravitational force due to the mass M of the core of the galaxy. This mass of the core is about two billion times the mass of our sun, strongly suggesting that a super massive black hole occupies the core.

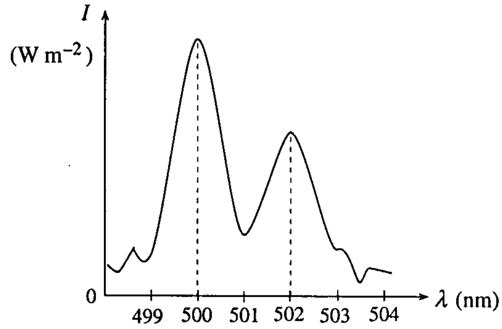


Figure (2)

(*a*) (i) Doppler effect for sound waves depends on three velocities. Name them.

(ii) These velocities are normally measured relative to the ground. What is the reason for this?

(*b*) Why does the Doppler effect for light depends only on two velocities?

(*c*) Starting from $f = f_0(1-\beta)$, derive the relationship $\upsilon = \frac{\Delta\lambda}{\lambda_0}c$. [**Hint**: When $\beta << 1$, $\frac{1}{1-\beta} = 1+\beta$].

(*d*) (i) From figure (2), determine the values of two wavelengths at which the intensities are peaked.

(ii) Which peak corresponds to the gas moving towards us?

(iii) If the gas were not moving relative to the core, what is the wavelength λ_0 (proper wavelength) of the light that would be detected by us?

(iv) What is the Doppler shift ($\Delta\lambda$) of the light from the gas moving away from us?

(v) Hence determine the speed υ of the gas. Round off your answer to the nearest integer ($c = 3.0 \times 10^8$ m s^{-1}).

(vi) Is $\beta << 1$? Justify your answer.

(*e*) (i) Determine the mass M of the core of the galaxy. ($G = 6.0 \times 10^{-11}$ N m^2 kg^{-2}).

(ii) What is believed to be occupying the core of the galaxy?

6. (*a*) (i) Velocity of sound (relative to air)
Velocity of the source (relative to air)
Velocity of the observer (relative to air) .... (01 mark)
(All correct)

(ii) Air is (considered to be) stationary relative to ground .... (01 mark)

(*b*) Light does not need a medium to travel OR Light travels even in vacuum
.... (01 mark)

(*c*) $f = f_0(1-\beta)$

$\frac{c}{\lambda} = \frac{c}{\lambda_0}(1-\beta)$ [For applying $c = f\lambda$] .... (01 mark)

$\lambda = \frac{\lambda_0}{1-\beta} = \lambda_0(1+\beta) = \lambda_0\left(1+\frac{v}{c}\right)$

$\lambda - \lambda_0 = \lambda_0 \frac{v}{c}$ .... (01 mark)

$v = \frac{\Delta\lambda}{\lambda_0} c$

(*d*) (i) $500\,\text{nm}$ and $502\,\text{nm}$ (for both) .... (01 mark)

(ii) Peak with $\lambda = 500\,\text{nm}$ OR Left peak OR peak with smaller wavelength
.... (01 mark)

(iii) $\lambda_0 = 501\,\text{nm}$ .... (01 mark)

(iv) $\Delta\lambda = 1\,\text{nm}$ .... (01 mark)

(v) $v = \frac{1}{501} \times 3 \times 10^8 = 5.988 \times 10^5$

$v = 6 \times 10^5\,\text{m s}^{-1}$ $(5.988 - 6.0) \times 10^5\,\text{m s}^{-1}$ .... (01 mark)
$(598800 - 600000)\,\text{m s}^{-1}$

[501 (not 500) should be substituted for λ_0]

(vi) $\beta = \frac{6 \times 10^5}{3 \times 10^8}$

$\beta = 2 \times 10^{-3}$ $(0.001996 - 0.002)$ .... (01 mark)

$\beta << 1$ is justified.

(*e*) (i) Let m be the mass of gas.

$\frac{mv^2}{r} = \frac{GmM}{r^2}$ .... (01 mark)

(No mark if the mass of the gas is omitted in the above equation.)

$M = \frac{v^2 r}{G}$

$r = 100 \times 3 \times 10^8 \times 365 \times 24 \times 3600$ .... (01 mark)
(For converting light years to m)

$M = \frac{(6 \times 10^5)^2 \times 100 \times 3 \times 10^8 \times 365 \times 24 \times 3600}{6.0 \times 10^{-11}}$

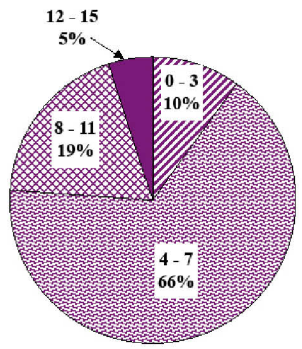
$M = 5.68 \times 10^{39}\,\text{kg}$ .... (01 mark)

$(5.65 - 5.70) \times 10^{39}\,\text{kg}$

(ii) Super massive black hole .... (01 mark)

Overall observations, conclusions and suggestions based on answers to Question 6 :

Scoring for the question



The sixth question has been selected by 77% of the candidates. Among the questions in part B, the question that has been selected by the maximum number of candidates is this. The question carries 15 marks. Of the candidates who answered this question,

10% have obtained marks within the interval of 0 - 3,

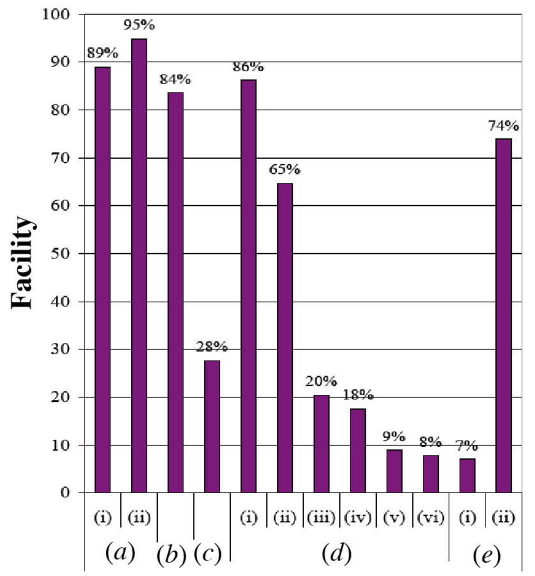
66% have obtained marks within the interval of 4 - 7,

19% have obtained marks within the interval of 8 - 11,

5% have obtained marks within the interval of 12 - 15.

The percentage of candidates who have scored more than 11 marks is 5% while 10% of the candidates have scored less than 4 marks.

Facility of parts and sub parts of the question



Parts and sub parts of question 6

This question has 12 parts and sub-parts. The Facility of five parts / sub-parts out of them are more than 70%. The sub-part that has the maximum facility is (*a*) (ii) and its facility is 95%. The sub-part that has the minimum facility is (*e*) (i) and its facility is 7%.

The 6th question is based on the application of 'Doppler Effect' theory for optical waves which comes under the unit 'Oscillations and waves'.

The maximum percentage of students i.e. 77% has selected this question from part B of paper II. The Facility of the parts / sub-parts (*a*) (i), (*a*) (ii), (*b*), (*d*) (i), (*e*) (ii) are at a higher level because those parts / sub-parts could be answered using the information given in the paragraph.

The facility of part (*c*) is 28%. Most of the students were unable to score marks fairly for deriving the given expression because the correct symbol of the velocity of light was not used.

Since the wave length related to sub-part (*d*) (ii) had not been identified, the facility has decreased to 20%. Further more, since the answers for the sub-parts (*d*) (iv), (v) and (vi) are based on the answer of (*d*) (iii), the marks have been lost and the Facility have been decreased to 18%, 9% and 8% respectively. In the answer for sub-part (*e*) (i), the equation that can be obtained when '$F = ma$' is used for the circular motion is $\frac{mv^2}{r} = \frac{GmM}{r^2}$. Students have lost 2 marks due to simplification of the equation leaving m, the mass of the gas and not knowing to substitute in the distance (r) given in light years in SI units. Therefore the facility has been decreased to 7%.

The cause for selecting this question by most of the students is the possibility of answering the given question by copying them down from the paragraph. The Facility of the parts which are answerable by copying down from the paragraph have been increased and the Facility of the other parts have been decreased.

7. Figure (1) shows the stress-strain curve for a uniform steel rod. Identify the points A, B and C.

An underground storage (S) of length 150 m, and width 6 m is to be constructed at a depth of 20 m from the ground level. Figure (2) shows the side view and figure (3) shows the front view of the storage. The weight of the soil existing above the roof of the storage is to be supported entirely by $30\text{ cm} \times 30\text{ cm}$ square steel columns (C). The soil has a uniform density of 3.0×10^3 kg m^{-3}.

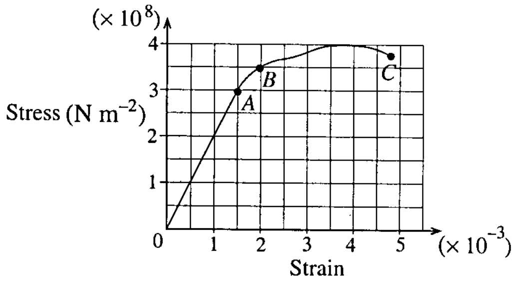


Figure (1)

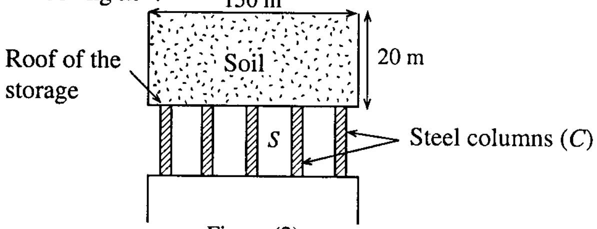


Figure (2)

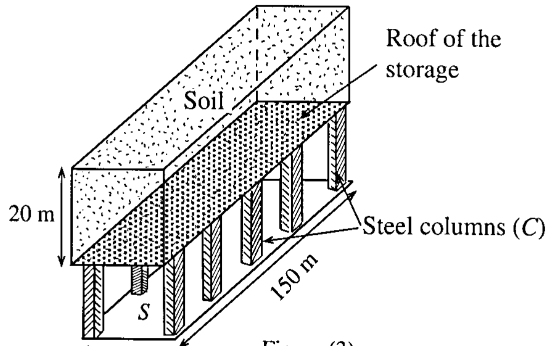


Figure (3)

(a) (i) Calculate the total weight of the soil that the columns must support.

(ii) What is the number of columns needed to keep the compressive stress on each column at $2 \times 10^8\text{ N m}^{-2}$? Assume that the weight of the soil is equally distributed among the columns. Neglect the mass of the roofing material.

(b) (i) Determine the Young's modulus of steel from the curve given in figure (1) above.

(ii) If the height of a steel column is 4.995 m what was its original uncompressed height?

(c) If the columns have a circular cross-section of radius 15 cm instead of the square cross-section of $30\text{ cm} \times 30\text{ cm}$ mentioned above, does the number of columns calculated in (a)(ii) above would be less, same or more? Give reasons for your answer.

7. (a) A - Proportional limit ....(01 mark)

B - Elastic limit ....(01 mark)

C - Breaking point ....(01 mark)

(i) Volume of the soil = $6 \times 150 \times 20$ ....(01 mark)

Mass of the soil = $6 \times 150 \times 20 \times 3 \times 10^3$ ....(01 mark)

(For multiplying the volume by 3×10^3)

Weight of the soil = 5.4×10^8 N ....(01 mark)

(ii) Let n be the number of columns needed, then

the stress on a single column $= \dfrac{5.4 \times 10^8}{n \times 30 \times 30 \times 10^{-4}}$ ....(01 mark)

(For dividing the weight by $n \times 30 \times 30 \times 10^{-4}$)

$$\frac{5.4 \times 10^8}{n \times 30 \times 30 \times 10^{-4}} = 2 \times 10^8$$ ....(01 mark)

(For equating the L.H.S. to 2×10^8)

$$n = \frac{5.4 \times 10^8}{9 \times 10^{-2} \times 2 \times 10^8}$$

$n = 30$ ....(01 mark)

(*b*) (i) Young's modulus = gradient of the stress vs. strain curve ....(01 mark)
(For the idea)

$= 2 \times 10^{11}\,\mathrm{N\,m^{-2}}$ ....(01 mark)

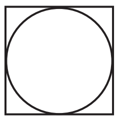
(ii) The corresponding strain for a stress of $2 \times 10^{8}\,\mathrm{N\,m^{-2}}$ is 0.001 (from the graph)
Let L be the uncompressed height of the column, then

$\frac{L - 4.995}{L} = 0.001$ OR $\left[\frac{2 \times 10^{8}}{(L - 4.995)} \times L = 2 \times 10^{11}\right]$................(01 mark)

$0.999\,L = 4.995$

$L = 5\,\mathrm{m}$ ....(01 mark)

(*c*) Area of cross section of the circular column $= \pi(15)^2 \approx 707\,\mathrm{cm}^2$
This area is less than 900 cm^2
OR
Area of cross section of a circular column is less than that of a square column OR Area of cross section of a square column is more than that of a circular column.
OR
For a diagram drawn as shown

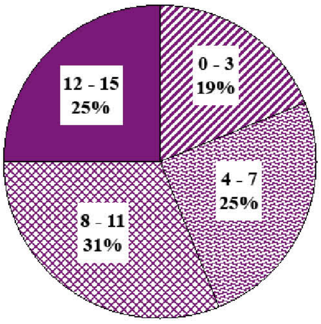


................(01 mark)

$\therefore$ Need more columns. ....(01 mark)

Overall observations, conclusions and suggestions based on answers to Question 7 :

Scoring for the question



The seventh question has been selected by 65% of the candidates only. This question carries 15 marks. Of the candidates who answered this question,

19% have obtained marks within the interval of 0 - 3,

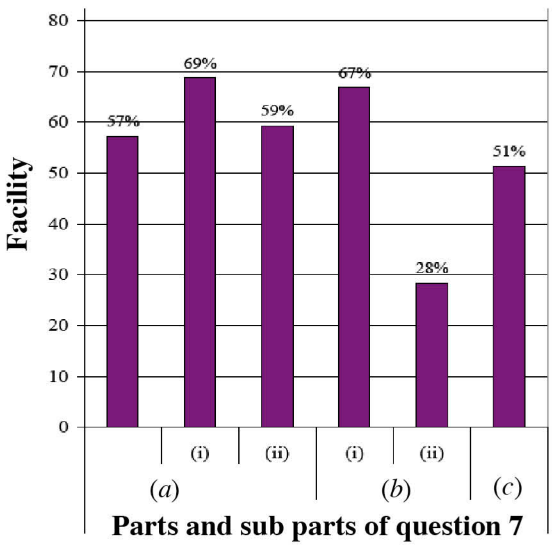
25% have obtained marks within the interval of 4 - 7,

31% have obtained marks within the interval of 8 - 11,

25% have obtained marks within the interval of 12 - 15.

The percentage of candidates who have scored more than 11 marks is 25% while 19% of the candidates have scored less than 4 marks.

Facility of parts and sub parts of the question



This question has six parts and sub-parts and the facility of only one of them is less than 30%. The sub-part that has the maximum facility is (*a*) (i) and its facility is 69%. The sub-part that has the minimum facility is (*b*) (ii) and its facility is 28%.

This question has been set from the sub unit of 'Elasticity' of the unit 'Properties of the matter' and a maximum number of students had answered the question successfully. Out of the students who selected this question, a 43% had failed to obtain relevant marks because they had not used the correct terminology words to introduce the points *A, B* and *C* on the graph. Some students had lost a mark because of the incorrect use of the 'proportion point' instead of the 'proportion limit'.

The facility of the sub-part (*a*) (i) is 69%. Since the students had not correctly understood the question when answering it and found the mass of the soil instead of the weight of the soil, one of the allocated three marks had been lost due to the above weakness.

The facility of the sub-part (*b*) (i) is 67%. Most of the students had correctly understood that the 'young modulus' had to be calculated by using the gradient of the straight line part of the given graph.

The facility of the sub-part (*b*) (ii) is 28%. In this sub-part, most of the students had lost marks because of not identifying the accurate length of the strain after compression.

The facility of the part (*c*) is 51%. A smaller percentage of students had lost both marks because of answering without comparing the surface area of the posts that have circular cross-sections and square cross-sections.

Students can have a higher level of achievement by practising to read the whole question well, produce complete answers and give reasons correctly when answering them.

8. Two metal plates A and B kept parallel to each other in a vacuum are connected to a voltage source as shown in figure (1). A molecular ion of mass m and charge $+q$, starting from rest from the plate A accelerates towards the metal plate B under the influence of the voltage V maintained between the plates.

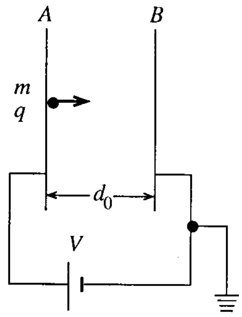


Figure (1)

(*a*) (i) Write down an expression for the kinetic energy gained by the ion when it reaches the plate B.

(ii) Derive an expression for the velocity υ acquired by the ion when it reaches the plate B.

(iii) If d_0 is the distance between the plates derive an expression for the time (t) taken by the molecular ion to reach the plate B.

(*b*) Suppose the metal plate B is now replaced with a metal wire mesh so that the ions moving through the region AB could enter a field free region and move towards an ion detector D placed at a distance S from the wire mesh B as shown in figure (2).

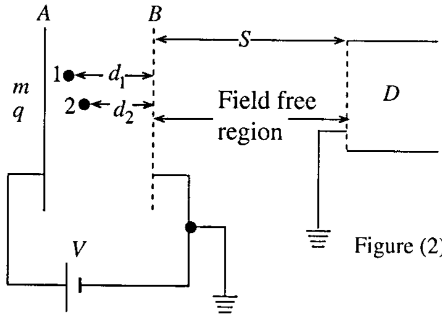


Figure (2)

Consider two molecular ions 1 and 2 of mass m and charge $+q$ suddenly being formed at time $t = 0$ at distances d_1 and d_2 from the wire mesh B as shown in figure (2). If they start from rest and move towards B under the electric field

(i) derive expressions for times t_1 and t_2 taken by the ions 1 and 2 to reach the mesh B, and indicate which ion reaches the mesh first.

(ii) derive expressions for velocities υ_1 and υ_2 of ions 1 and 2 when they reach the mesh B. Indicate which ion has the higher velocity when they reach B.

(iii) Derive an expression in terms of t_1, t_2, υ_1 and υ_2 for the suitable value for the distance S at which the detector D has to be placed so that it detects both ions 1 and 2 at the **same time** as shown in figure (3).

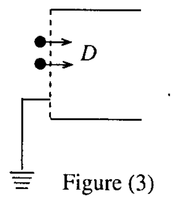


Figure (3)

8. (*a*) (i) Kinetic energy gained $= qV$ ....(01 mark)

(No mark for $\frac{1}{2}mv^2$)

(ii) $$qV = \frac{1}{2}mv^2$$ ....(01 mark)

$$\therefore v^2 = \sqrt{\frac{2qV}{m}}$$ ....(01 mark)

(iii) Applying $S = \frac{1}{2}at^2$

Where $a = \frac{qV}{md_0}$ ....(01 mark)

$$d_0 = \frac{1}{2}\left(\frac{qV}{md_0}\right)t^2$$

$$t = d_0\sqrt{\frac{2m}{qV}}$$ ....(01 mark)

(*b*) (i) $d_1 = \frac{1}{2}\left(\frac{qV}{md_0}\right)t_1^2$ ....(01 mark)

$\therefore\ t_1 = \sqrt{\frac{2\,m\,d_1\,d_0}{qV}}$ ....(01 mark)

Similarly $t_2 = \sqrt{\frac{2\,m\,d_2\,d_0}{qV}}$ ....(01 mark)

(Since $d_1 > d_2$, from the above expressions), $t_2 < t_1$ ....(01 mark)
Ion 2 reaches the mesh first.

(ii) Applying $qV' = \frac{1}{2}mv^2$

$qV\frac{d_1}{d_0} = \frac{1}{2}mv_1^2$ (For LHS) ....(01 mark)

{Alternative Method : Applying $v^2 = u^2 + 2as$; $v_1^2 = 2\frac{qV}{md_0}d_1$ ....(01)}

$\therefore\ v_1 = \sqrt{\frac{2qVd_1}{d_0 m}}$ ....(01 mark)

Similarly

$v_2 = \sqrt{\frac{2qVd_2}{d_0 m}}$ ....(01 mark)

(Since $d_1 > d_2$, from the above expressions,) $v_1 > v_2$ ....(01 mark)
Ion 1 has the higher velocity.

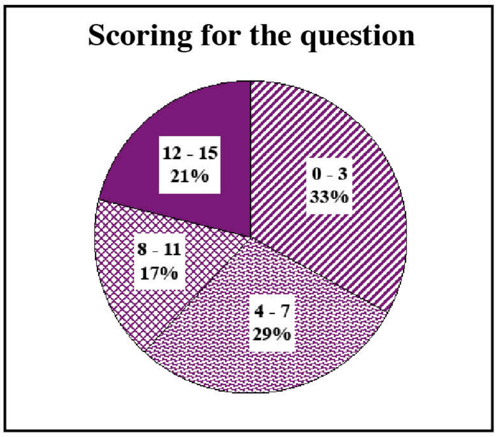
(iii) The detector will detect both ions simultaneously if,

$t_1 + \frac{s}{v_1} = t_2 + \frac{s}{v_2}$ ....(01 mark)

$S\left(\frac{1}{v_2} - \frac{1}{v_1}\right) = t_1 - t_2$

$\therefore\ S = (t_1 - t_2)\frac{v_1 v_2}{v_1 - v_2}$ ....(01 mark)

Overall observations, conclusions and suggestions based on answers to Question 8 :



The eighth question has been selected by 25% of the candidates only. This question carries 15 marks. Of the candidates who answered this question,

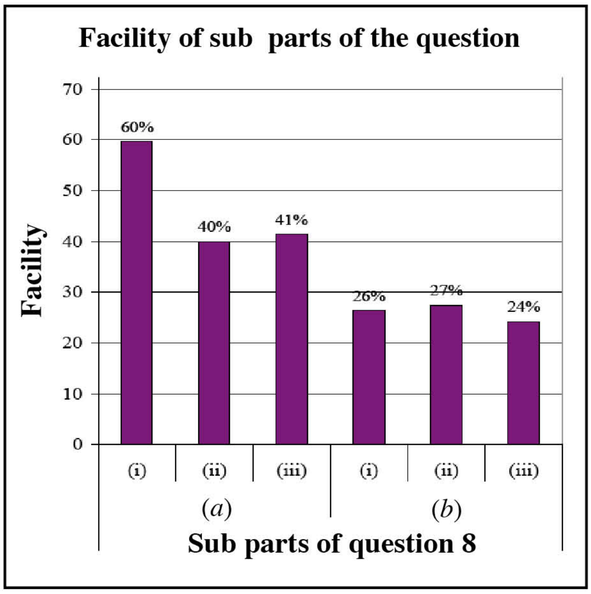
33% have obtained marks within the interval of 0 - 3,

29% have obtained marks within the interval of 4 - 7,

17% have obtained marks within the interval of 8 - 11,

21% have obtained marks within the interval of 12 - 15.

The percentage of candidates who have scored more than 11 marks is 21% while 33% of the candidates have scored less than 4 marks.



This question has six sub-parts. The Facility of three sub-parts out of them are lower than 30%. The sub-part that has the maximum facility is (*a*) (i) and its facility is 60%. The sub-part that has the minimum facility is (*b*) (iii) and its facility is 24%.

This question is set related to the unit 'Electric Fields'. A higher number of students have scored 40% or more than that for all sub-parts of part (*a*), out of the sub-parts of this question the required statements could have been obtained by applying the equation $W = qV$ and equations on motion for the motion of a charged particle in electric fields. Obtaining of these simple derivations have shown average Facility.

The Facility of all sub-parts of part (*b*) are less than 30%. In answering this question, it is necessary to reach the conclusions logically by comparing the motion of two charged particles connecting the answers to part (*a*). The achievement level has been decreased because of the weaknesses of students in such logical answering.

In overall view, the achievement of the students for this question takes a lower value. Students had shown weaknesses in generating equations, derivations and providing answers logically using those results.

Weaknesses of students could be minimized by getting them to practise in the classroom, and making them understand the concepts and get them to apply relevant formulae obtaining required derivations by substituting them and improving their relevant logical reasoning skills.

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

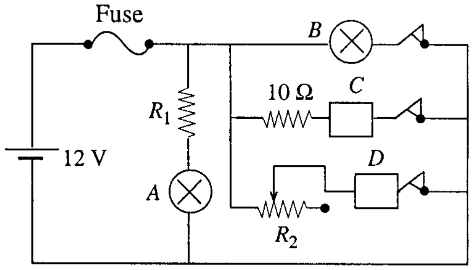


Figure (1)

(A) (*a*) Figure (1) shows a circuit powered by a 12 V battery with negligible internal resistance. The two bulbs *A* and *B* are rated at 3 V, 0.1 A and 12 V, 2 A respectively. *C* and *D* are two devices having internal resistance 6 Ω each.

(i) Calculate the value of resistor R_1 that would provide the rated voltage to bulb *A*.

(ii) Calculate the voltage across *C* and the power dissipated in the 10 Ω resistor.

(iii) In order to be able to limit the current through *D* between 0.5 A and 2 A, what should be the value of the variable resistor R_2?

(iv) Suppose three fuses with current ratings 4 A, 5 A and 10 A are given. In order to make it possible to operate all devices simultaneously, under the above conditions, which fuse would be most suitable to be connected to this circuit?

(*b*) Electrical circuits such as the one above are constructed by mounting electrical components on insulated boards, and joining the terminals of the components by copper wires. In modern circuits, however, such connections are made by thin copper strips printed on insulated boards.

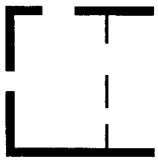


Figure (2)

A part of a printed circuit board is shown in figure (2), and an enlarged diagram of one copper strip is shown in figure (3).

For all calculations below, take the thickness of copper strip, *h*, as 0.3 mm.

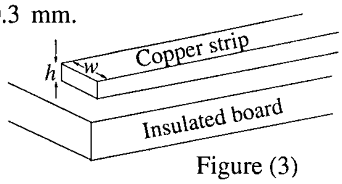


Figure (3)

(i) Calculate the resistance of a 10 mm long copper strip of width w = 1 mm. (Resistivity of copper is 1.8×10^{-8} Ω m.)

(ii) Calculate the voltage across this strip and its power dissipation, when a current of 0.1 A passes through it.

(iii) If all the heat dissipated in one second is accumulated in the strip without being lost to the environment, what will be its increase in temperature? (Specific heat capacity and density of copper are 400 J kg^{-1} K^{-1} and 9×10^3 kg m^{-3} respectively.)

(iv) Copper strips carrying large currents are normally made wider than those carrying small currents.

9. (A) (*a*) (i) $12 - 3 = 0.1 \times R_1$ .... (01 mark)

$R_1 = 90\,\Omega$ .... (01 mark)

(ii) $12 = i \times (10 + 6)$

$i = 0.75$ A .... (01 mark)

Power dissipation $= (0.75)^2 \times 10$

$= 5.625$ W .... (01 mark)

Voltage across *C* $= 0.75 \times 6$

$= 4.5$ V .... (01 mark)

(iii) $12 = 0.5 \times (R_2 + 6)$

$R_2 = 18\,\Omega$ .... (01 mark)

(iv) Maximum total current = 4.85 A. Therefore, the 5 A fuse is suitable

.... (01 mark)

(For determining the total current and the selection of the fuse) (*b*) (i) Using $R = \dfrac{\rho l}{A}$, ...(01 mark)

(For the use of this equation)

Resistance $= \dfrac{1.8 \times 10^{-8} \times 10 \times 10^{-3}}{0.3 \times 10^{-3} \times 1 \times 10^{-3}}$ ....(01 mark)

$= 6 \times 10^{-4}\ \Omega$ ....(01 mark)

(ii) Voltage across the strip $= 6 \times 10^{-4} \times 0.1$

$= 6 \times 10^{-5}$ V ....(01 mark)

Power dissipation $= 6 \times 10^{-6}$ W ....(01 mark)

(iii) Dissipated power $= ms\Delta\theta$

$6 \times 10^{-6} = 10 \times 10^{-3} \times 0.3 \times 10^{-3} \times 1 \times 10^{-3} \times 9 \times 10^{3} \times 400 \times \Delta\theta$

(For correct substitution)................(01 mark)

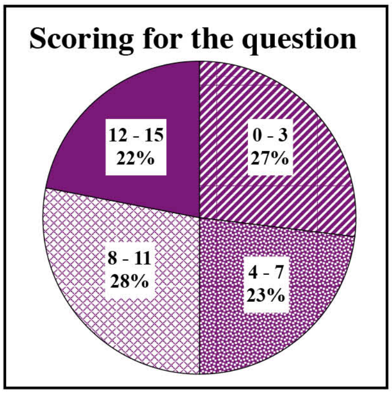
$\Delta\theta = 5.5 \times 10^{-4}$ °C (OR K) ....(01 mark)

(iv) (1) Larger width reduces resistance (and therefore reduces power dissipation)

(2) Larger width increases heat transfer to the environment OR Larger width increases area exposed to air ....(01 mark)

(both correct)

Overall observations, conclusions and suggestions based on answers to Question 9(A) :



Only 25% of the candidates have selected the question 9(A). This question carries 15 marks. Of the candidates who answered this question,

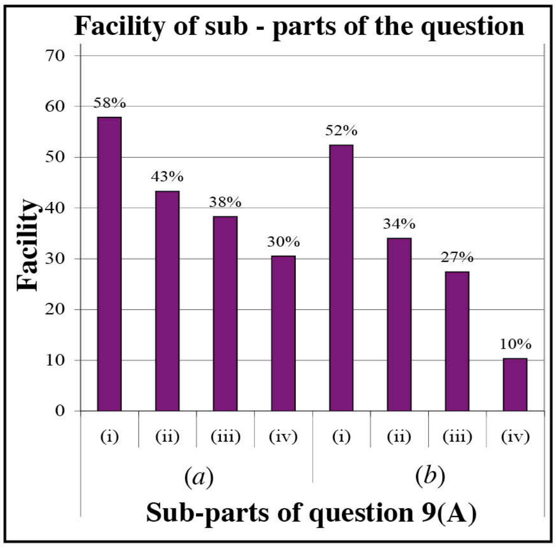
27% have obtained marks within the interval of 0 - 3,

23% have obtained marks within the interval of 4 - 7,

28% have obtained marks within the interval of 8 - 11,

22% have obtained marks within the interval of 12 - 15.

The percentage of candidates who have scored more than 11 marks is 22% while 27% of the candidates have scored less than 4 marks.



This question has eight sub-parts. The Facility of three sub-parts out of them are 30% or less than that. The sub-part (*a*) (i) has the maximum facility and its facility is 58%. The sub-part (*b*) (iv) has the minimum facility and its facility is 10%.

Only 25% of the candidates have selected this question. The sub-part (*a*) (i) has the maximum facility. Its facility is 58%. This sub-part measures the ability of applying basic principles of electricity. The Facility of sub-parts (*a*) (ii) and (*a*) (iii) are 43% and 38% respectively. In these questions it is required to apply the Kerchoffs' Second Law, i.e. $\sum E = \sum IR$ (which is a basic formula found in electricity) for a closed circuit, applying the Ohm's Law $V = IR$ to find the voltage through C and to calculate the power dissipation of the resistance 10 Ω.

The facility of the sub-part (*a*) (iv) is 30%. In order to select the most appropriate fuse out of the given fuses 4A, 5A, and 10A, it is required to calculate the maximum current that can be obtained from the cell so that all the instruments in the circuit could be activated altogether under the given conditions. In this sub-part it was difficult for students to compute the value of the current accurately since it had to be sorted out from the values calculated in the sub-parts (*a*) (i), (*a*) (ii) and (*a*) (iii). It is important to direct the students for concept formation and applications of principles.

In sub-part (*b*) (i), the resistance of a given copper strip should be calculated by using the equation $R = \dfrac{\rho l}{A}$. The facility of this sub-part is 52%. Similarly the facility of sub-part (*b*) (ii) is 34%. In this sub-part, the voltage through the copper strip should be calculated applying the Ohm's Law $V = IR$ and the power dissipation should be calculated by applying $P = IV$. The facility of the sub-part (*b*) (iii) is 27%. In this sub-part, the temperature increase $\Delta\theta$ could be calculated by applying the formula, "the power dissipation $= ms\Delta\theta$". Most of the students were unable to get the correct answers because of the weaknesses in the areas such as simplifying mathematical expressions and transforming the given units into SI units.

Students had to answer the sub-part (*b*) (iv) which has the minimum facility of 10%, by using logical thinking. Since the power dissipation increases when the current is increased, in order to control the power dissipation, the copper strips are made wider. When the strips are widened, the heat transmission to the environment also increases. Therefore the copper strips do not get heated. Students' attention must be directed on such practical applications.

(B) (*a*) Write down the truth table for a 2-input AND gate. Use symbols A and B for inputs and F for output.

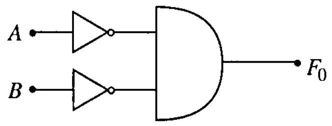


Figure (1)

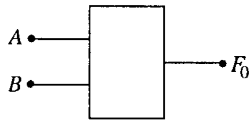


Figure (2)

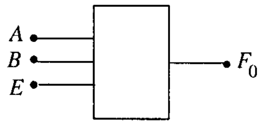


Figure (3)

(*b*) The block diagram of the circuit shown in figure (1) is given in figure (2).

(i) Write down the truth table for the circuit shown in figure (1).

(ii) Hence, show that the circuit shown in figure (1) operates as follows:

$F_0 = 1$ only when $A = 0$ and $B = 0$,

and $F_0 = 0$ otherwise.

(*c*) Suppose now you use a 3-input AND gate in the circuit shown in figure (1) above instead of a 2-input AND gate. Let the third input be E. Then the block diagram will take the form shown in figure (3).

(i) Draw the circuit diagram corresponding to the block diagram in figure (3).

(ii) By filling the two truth tables shown, show that the circuit will operate similar to the circuit given in figure (1) when $E = 1$, and the output $F_0 = 0$ when $E = 0$ irrespective of the values of A and B.

A	B	E	F_0
0	0	1	
0	1	1	
1	0	1	
1	1	1	

A	B	E	F_0
0	0	0	
0	1	0	
1	0	0	
1	1	0	

(*d*) Now draw a circuit diagram using a 3-input AND gate and **one** NOT gate to operate as follows.

The output $F_1 = 1$ only when $A = 0$, $B = 1$ and $E = 1$

$F_1 = 0$ when $E = 0$

(*e*) Similarly draw two separate circuits using 3-input AND gates and NOT gates, to operate as follows.

(i) Output $F_2 = 1$ only when $A = 1$ and $B = 0$ and $E = 1$

$F_2 = 0$ when $E = 0$

(ii) Output $F_3 = 1$ only when $A = 1$ and $B = 1$ and $E = 1$

$F_3 = 0$ when $E = 0$

(*f*) Now combine all four **circuits** drawn under (*c*)(i), (*d*), (*e*)(i) and (*e*)(ii) and draw a single circuit so that it will have only 3 common inputs A, B and E, and four outputs F_0, F_1, F_2 and F_3.

The circuit that you have drawn should conform with the block diagram given in figure (4).

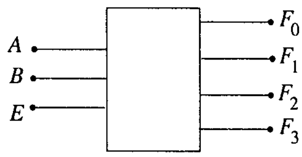


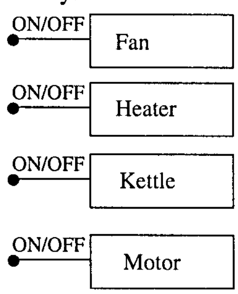
Figure (4)

(*g*) Suppose you are given four devices, an electric fan, an electric heater, an electric kettle and an electric motor which can be switched ON or OFF with logic signals 1 or 0 respectively.

(i) Draw a block diagram to show how you would connect the devices shown in figure (5) to the block diagram given in figure (4) so that any one of them can be selected and operated, one at a time.

Write down the combination of appropriate logic signals that you would apply to the inputs A and B to select each device.

(ii) How would you keep all the devices in non operative condition using logic signals?

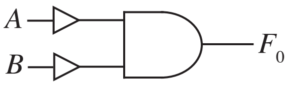


9. (B) (*a*)

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

.... (01 mark)

(*b*) (i)

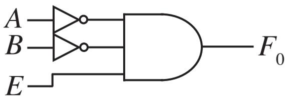


A	B	F_0
0	0	1
0	1	0
1	0	0
1	1	1

.... (01 mark)
(For the truth table)

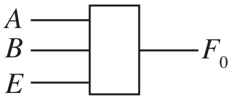
(ii) Truth table shows that $F_0 = 1$ only when $A = 0$ and $B = 0$, and it is zero under all other combinations .... (01 mark)

(*c*) (i)



.... (01 mark)

(ii)



A	B	E	F_0
0	0	1	1
0	1	1	0
1	0	1	0
1	1	1	0

Truth table 1

A	B	E	F_0
0	0	0	0
0	1	0	0
1	0	0	0
1	1	0	0

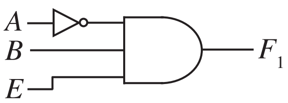
Truth table 2

For correctly drawing the truth table 1 .... (01 mark)

For correctly drawing the truth table 2 .... (01 mark)

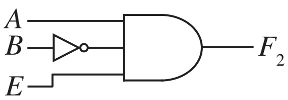
Above tables show that the truth table 1 is identical to the truth table given under *b* (i) when $E = 1$

(*d*)



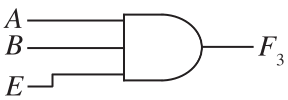
.... (01 mark)

(*e*) (i)



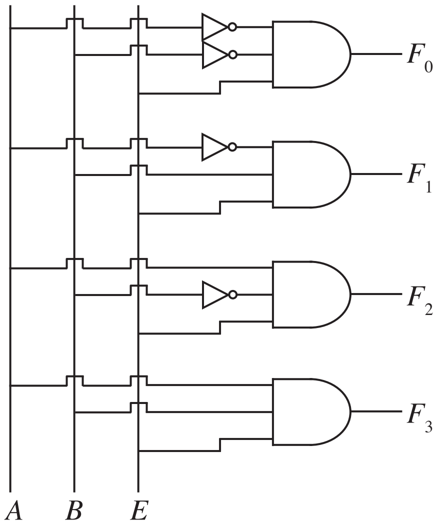
.... (01 mark)

(ii)



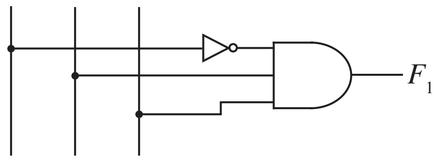
.... (01 mark)

(*f*)



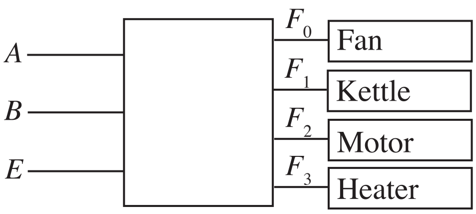
.... (02 mark)

(01 mark is awarded for correct interconnections even when the sub circuits are wrong)



The connections shown above are also accepted as correct.

(*g*) (i)



.... (01 mark)

Input conditions to operate the fan : $A = 0, B = 0, E = 1$

Input conditions to operate the Kettle : $A = 0, B = 1, E = 1$

Input conditions to operate the Motor : $A = 1, B = 0, E = 1$

Input conditions to operate the Heater : $A = 1, B = 1, E = 1$

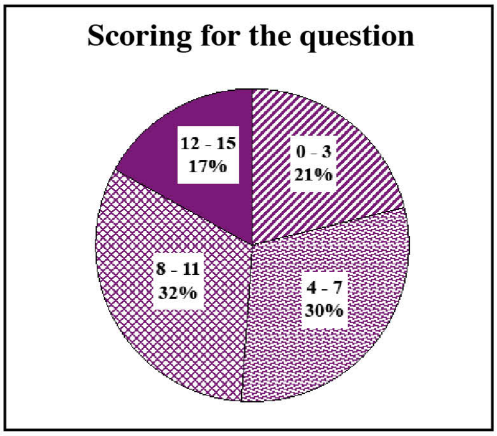
.... (02 mark)

(All 4 correct - 02, any 3 correct - 01)

(Devices can be connected to block diagram in any order, but the appropriate input conditions should be given in order to earn the marks)

(ii) Keep $E = 0$ .... (01 mark)

Overall observations, conclusions and suggestions based on answers to Question 9(B) :



Only 42% of the candidates have selected the question 9(B). This question carries 15 marks of the candidates who answered this question,

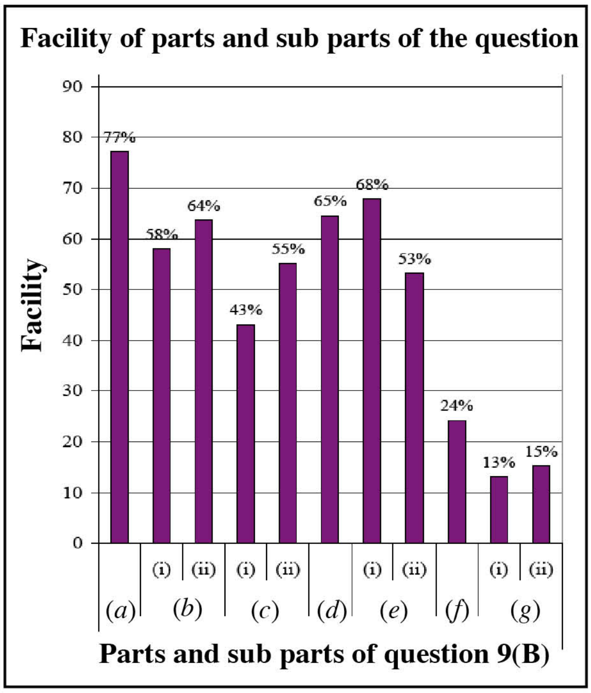
21% have obtained marks within the interval of 0 - 3,

30% have obtained marks within the interval of 4 - 7,

32% have obtained marks within the interval of 8 - 11,

17% have obtained marks within the interval of 12 - 15.

The percentage scoring above 11 for this question is 17% while 21% have scored less than 4 marks.



This question has 11 parts and sub-parts. Out of them, the Facility of three parts / sub-parts are less than 30%. The facility of part (*a*) is the maximum and its facility 77%. The facility of sub-part (*g*) (i) is the minimum and its facility is 13%.

A less percentage of students have selected the last questions of paper II. Among those questions, the question 9 (B) has a considerable selection of 42%. Greater number of parts and sub-parts of this question were scored marks within an interval of 53% to 77%, for the reasons such as, the question was based on an easy and attractive subject content of electronics and the answers could be provided by using truth tables and logic gates avoiding lengthy calculations.

Drawing at least one of the combined gates contained in a circuit incorrectly and giving answers based on it had caused minimization of the Facility of part (*f*) and sub-parts of (*g*).

A high preference and a high performance could be expected for this type of questions by discussing and practising of answering such questions in the classroom.

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

(A) (*a*) Consider a pond of cross section 2 m × 2 m, and containing pure water constantly being exposed to direct sunlight. (see figure 1) The amount of solar heat radiation falling on the pond is 1000 W m^{-2} and assume that it is constant for the calculations below.

Furthermore assume that solar heat is incident normal to the water surface at all times, no heat transfer occurs between water and the walls of the pond and that **no heat is absorbed by water directly from sunlight**. All the heat is absorbed by a blackened metal sheet placed at the bottom of the pond and then transferred to water near the bottom by conduction.

(i) If the amount of heat absorbed by the metal sheet over a 7 minute period entirely contributed to raise the temperature of a thin layer of water of mass 40 kg just above the metal sheet, how much will be the temperature rise in water? (Take specific heat capacity of water as 4200 J kg^{-1} K^{-1})

(ii) Let densities of water at 0 °C and at θ °C be ρ_0 and ρ_θ respectively. Obtain an expression for ρ_θ in terms of ρ_0, θ and the volume expansivity of water γ.

(iii) Explain why convection currents will occur when water is heated as mentioned in (*a*) (i) above.

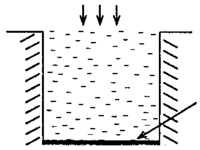


Figure (1)

(*b*) A solar pond is a pond used to collect and store solar energy as heat. Solar heat reaching the bottom of such a pond is trapped by suppressing convection currents.

A very simple model of a solar pond with a 2 m × 2 m area is shown in figure (2). It has three distinct layers. The top layer has relatively pure water. The bottom layer has a very high salt concentration resulting a high density. The density is uniform throughout that layer. In the middle layer, the salt concentration and density decreases gradually with height.

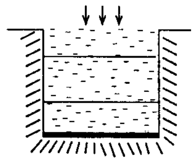


Figure (2)

For the following parts, assume that the initial temperature of water throughout the pond is 30 °C.

(i) In a practical solar pond, the temperature of the bottom layer can reach about 90 °C. If the mass of water in this layer is 6000 kg and if it receives heat radiation at the constant rate of 1000 W m^{-2}, how long will water take to reach 90 °C? Assume that this heat is entirely used to increase the temperature of water, and that salt water has the same specific heat capacity as pure water.

(ii) Taking ρ_0 = 1554 kg m^{-3} for salt water, calculate the density of salt water at 90 °C. (Volume expansivity of salt water is 4 × 10^{-4} K^{-1})

(iii) If the top layer remains at 30 °C, can there be convection currents from the bottom to the top layer under the above condition? Justify your answer. (Take density of pure water at 30 °C as 1000 kg m^{-3}.)

(iv) (1) When the temperature of the bottom layer increase from 30 °C to 90 °C, calculate the amount of heat stored in that layer.

(2) Suggest a method to use this energy for a practical purpose.

(v) In a practical solar pond, heat loss through the walls must be minimised. If a styrofoam layer of thickness 10 cm is used as an insulation between water and walls of the pond, and if the temperature of the walls stays at 40 °C while water is at 90 °C, what will be the rate of heat loss per m^2 through styrofoam? (Heat conductivity of styrofoam is 0.01 W m^{-1} K^{-1}.)

10.(A) (*a*) (i) $\Delta Q = ms\Delta\theta$ OR $Q = ms\theta$ .... (01 mark)

$40 \times 4200 \times \Delta\theta = 1000 \times 7 \times 60 \times 4$

$\Delta\theta = \dfrac{1000 \times 7 \times 60 \times 4}{40 \times 4200}$ .... (01 mark)

$= 10\,°C$ .... (01 mark)

(ii) $V_\theta = V_0\,(1 + \gamma\theta)$ ....(01 mark)

Using $\rho = \dfrac{m}{V}$ $\quad \dfrac{m}{\rho_\theta} = \dfrac{m}{\rho_0}\,(1 + \gamma\theta)$

$\rho_\theta = \dfrac{\rho_0}{1 + \gamma\theta}$ ....(01 mark)

(iii) Since $\rho_\theta < \rho_0$, water will rise ....(01 mark)

(*b*) (i) $m s \theta = \dfrac{Q}{t} \times t$

$t = \dfrac{6000 \times 4200 \times (90 - 30)}{1000 \times 4}$ ....(01 mark)

$= 378000\,\text{s}$ OR 6300 min. OR 105 h ....(01 mark)

(ii) $\rho_\theta = \dfrac{1544}{1 + 4 \times 10^{-4} \times 90}$ ....(01 mark)

$= 1500\ \text{kg m}^{-3}$ ....(01 mark)

(iii) This density is greater than the density of pure water at $30\,°\text{C}$.
Therefore, water will not rise to the top layer ....(01 mark)
[If a wrong value is obtained for ρ_θ, no mark is awarded for part (*b*)(iii)]

(iv) 1. Amount of heat stored $= 6000 \times 4200 \times (90 - 30)$

$= 1.512 \times 10^9\ \text{J}$ ....(01 mark)

2. (i) To produce hot water by circulating (cold) water through (copper) tubes (which are laid in the bottom layer) OR

(ii) To generate electricity (by operating thermoelectric devices) using the temperature difference between bottom and the top layers

................(01 mark)
(Any one of the methods)

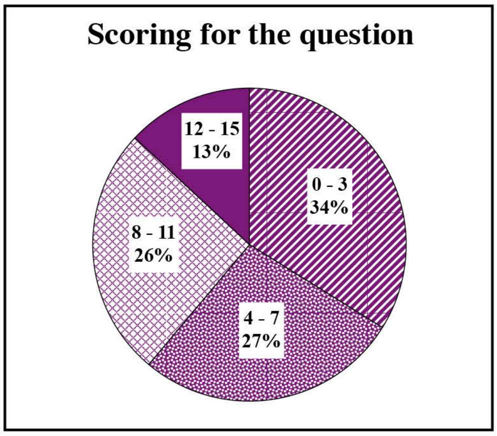
(v) Using $\dfrac{Q}{t} = \dfrac{kA\Delta\theta}{l}$ ....(01 mark)

Rate of heat loss per unit area

$= \dfrac{0.01 \times (90 - 40)}{0.1}$

$= 5\ \text{W m}^{-2}$ ....(01 mark)
(With the correct unit)

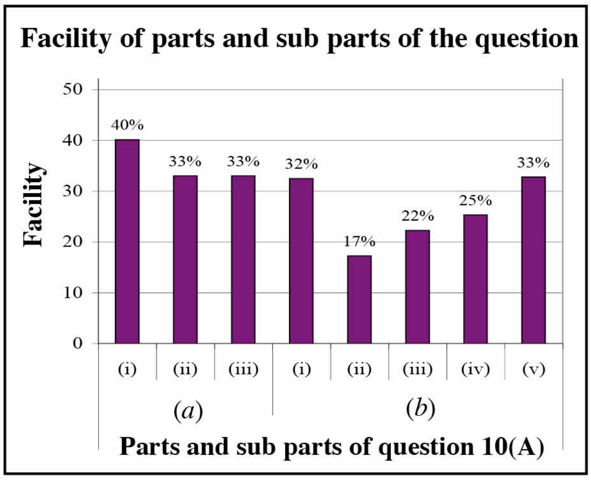
Overall observations, conclusions and suggestions based on answers to Question 10(A) :



Only 30% of the candidates have selected this question. The question carries 15 marks. Of the candidates who answered this question,

34% have obtained marks within the interval of 0 - 3,
27% have obtained marks within the interval of 4 - 7,
26% have obtained marks within the interval of 8 - 11,
13% have obtained marks within the interval of 12 - 15.

The percentage scoring above 11 for this question is 13% while 34% have scored less than 4 marks.



This question has eight sub-parts. Out of them, the Facility of three sub-parts are less than 30%. The sub-part that has the maximum facility is (*a*) (i) and its facility is 40%. The sub-part that has the minimum facility is (*b*) (ii) and its facility is 17%.

This question is based on some concepts in the unit 'Heat'. The Facility of all the sub-parts of this question are 40% or less than that. The answers had to be created connecting the subject matters of Thermometry, Thermo Expansion and Heat Conductivity. Incorrect applications of equations corresponding to each sub-part has caused the failures of getting the correct answers.

In this question, sub-part (*a*) (i) has the maximum facility. Most of the students had lost two marks because of substituting the values in the equation $\Delta Q = ms\,\Delta\theta$ without considering the quantity of heat, the time and the area. The facility of this sub-part is 40% and it is a low achievement level.

The sub-part (*a*) (ii) has a low achievement level of 33% because the students have failed to decide the correct equation and to build up a statement for density based on the equation. The minimum facility has shown by the sub-part (*b*) (ii). Its facility is 17%. Failure to construct the relevant equation in sub-part (*a*) (ii) has caused to reduce the marks obtained for sub-part (*b*) (ii).

Further more, the correct answer had not been able to be obtained because of substituting an incorrect value in the equation $\rho_\theta = \rho_0 / (1 + \gamma\,\theta)$ taking θ as the difference of the temperature of the salt solution 90^0C and the initial temperature of the water of the pond 30^0C instead of the correct value 90^0C.

This is the question which shows the least performance of the Essay Part of the Paper II. It is necessary to launch a remedial programme in the classroom to uplift the students' performance through practising to read the question carefully, understand and memorise the relevant equations while substitute the equations correctly, hence provide the answers logically.

(B) In 1924 Louis de Broglie proposed that a particle having a linear momentum p can be described by a matter wave known as a de Broglie wave.

(*a*) (i) Write down an expression for the de Broglie wavelength (λ), in terms of the Planck constant h and p.

(ii) For a particle of mass m and kinetic energy E, rewrite the above expression in terms of h, m and E.

(*b*) A vessel is filled with helium gas at temperature T and atmospheric pressure of 10^5 Pa.

(i) Write down an expression for the mean kinetic energy E of helium atoms in terms of the Boltzmann constant k and T.

(ii) Using the expression derived in (*a*) (ii) above write down an expression for the mean de Broglie wavelength λ of helium atoms in terms of h, k, T and mass m of a helium atom.

(iii) Calculate λ at T = 27 °C. (The numerical values of the constants are given at the end of the question.) [Take $\sqrt{8.4} = 3$]

(iv) If a is the mean distance between helium atoms, by taking the total volume of helium gas to be Na^3, where N is the number of helium atoms present in the vessel, determine a. Consider helium to be an ideal gas. [Take $\sqrt[3]{60} = 4$].

(v) Can the helium atoms be treated as particles under these conditions? Give reasons for your answer.

(vi) If the volume of the gas could be decreased without changing its pressure by cooling it down, at a certain temperature T' the mean de Broglie wavelength of helium atoms can be made equal to the mean distance between helium atoms. Derive an expression for T', in terms of h, m and k.

(Planck constant $h = 6.6 \times 10^{-34}$ J s; Mass of a helium atom $m = 6.0 \times 10^{-27}$ kg;
Boltzman constant $k = 1.4 \times 10^{-23}$ J K^{-1})

10.(B) (*a*) (i) $\lambda = \dfrac{h}{p}$ ....(01 mark)

(ii) $E = \dfrac{p^2}{2m}$ ....(01 mark)

(or $E = \dfrac{1}{2}mv^2$ and $p = mv$)

$\lambda = \dfrac{h}{\sqrt{2mE}}$ ....(01 mark)

(*b*) (i) $E = \dfrac{3}{2}kT$ ....(01 mark)

(ii) $\lambda = \dfrac{h}{\sqrt{3mkT}}$ ....(01 mark)

(iii) $\lambda = \dfrac{6.6 \times 10^{-34}}{\sqrt{3 \times 6 \times 10^{-27} \times 1.4 \times 10^{-23} \times 300}}$ ....(01 mark)
(For correct substitution)

$\lambda = \dfrac{6.6 \times 10^{-34}}{\sqrt{9 \times 8.4 \times 10^{-48}}}$

$\lambda = \dfrac{6.6 \times 10^{-34} \times 10^{24}}{9} \left[\dfrac{6.6 \times 10^{-10}}{9}\right]$ ....(01 mark)

$\lambda = 7.3 \times 10^{-11}$ (7.3×10^{-11} to 7.6×10^{-11}) m ....(01 mark)

(iv) Applying

$PV = NkT$ .... (01 mark)

$10^5 Na^3 = NkT$ .... (01 mark)

$$a^3 = \frac{1.4 \times 10^{-23} \times 300}{10^5}$$

$a = \sqrt[3]{42} \times 10^{-9}$ .... (01 mark)

$a = 3.5 \times 10^{-9}\,\text{m}$

(v) Yes, (can be treated as particles) .... (01 mark)

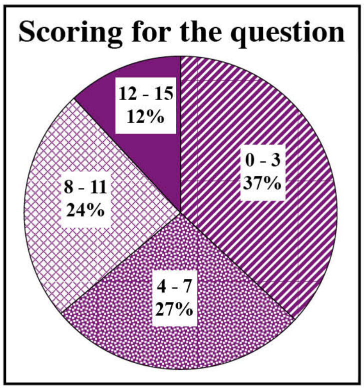
$\lambda < a$ [(Mean) de Broglie wavelength is less than the (mean) distance between the atoms] .... (01 mark)

(vi) $\dfrac{h}{\sqrt{3mkT'}} = \left[\dfrac{kT'}{10^5}\right]^{\frac{1}{3}}$ .... (01 mark)

$$T'^{\frac{5}{6}} = \frac{h \times 10^{\frac{5}{3}}}{\sqrt{3m} \times k^{\frac{5}{6}}} \quad \text{OR} \quad T' = \left[\frac{h \times 10^{\frac{5}{3}}}{\sqrt{3m} \times k^{\frac{5}{6}}}\right]^{\frac{5}{6}} \quad \text{OR}$$

$T' = \left[\dfrac{h^6 \times 10^{10}}{27m^3 k^5}\right]^{\frac{1}{5}}$ .... (01 mark)

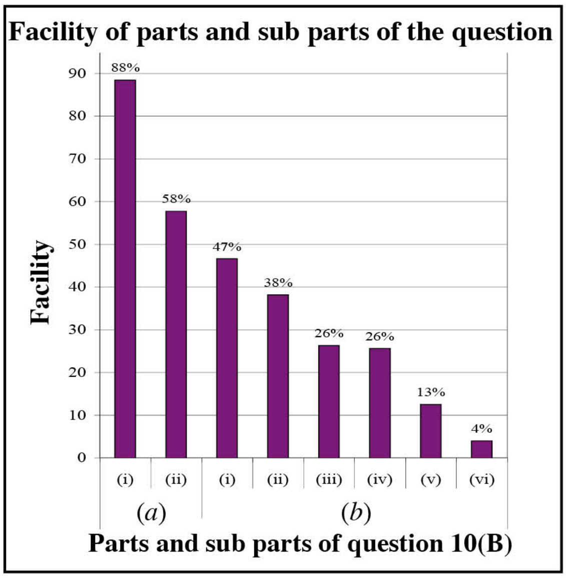
Overall observations, conclusions and suggestions based on answers to Question 10(B) :



Question 10 (B) has been selected by 33% of the candidates only. This question carries 15marks. Of the candidates who answered this question,

37% have obtained marks within the interval of 0 - 3,
27% have obtained marks within the interval of 4 - 7,
24% have obtained marks within the interval of 8 - 11,
12% have obtained marks within the interval of 12 - 15.

The percentage of candidates scoring above 11 for this question is 12% while 37% of the candidates have scored less than 4 marks.



This question has eight sub-parts and out of them, Facility of four sub-parts are less than 30%. The sub-part (*a*) (i) has the maximum facility and its facility is 88%. The sub-part (*b*) (vi) has the least facility and its facility is 4% only.

This question is based on the unit 'Matter and Radiation'. The answers for the sub-parts (*a*) (i), (*a*) (ii), (*b*) (i) and (*b*) (ii) are the expressions that can be obtained from basic equations and their derivations. Therefore the Facility of these sub-parts are high.

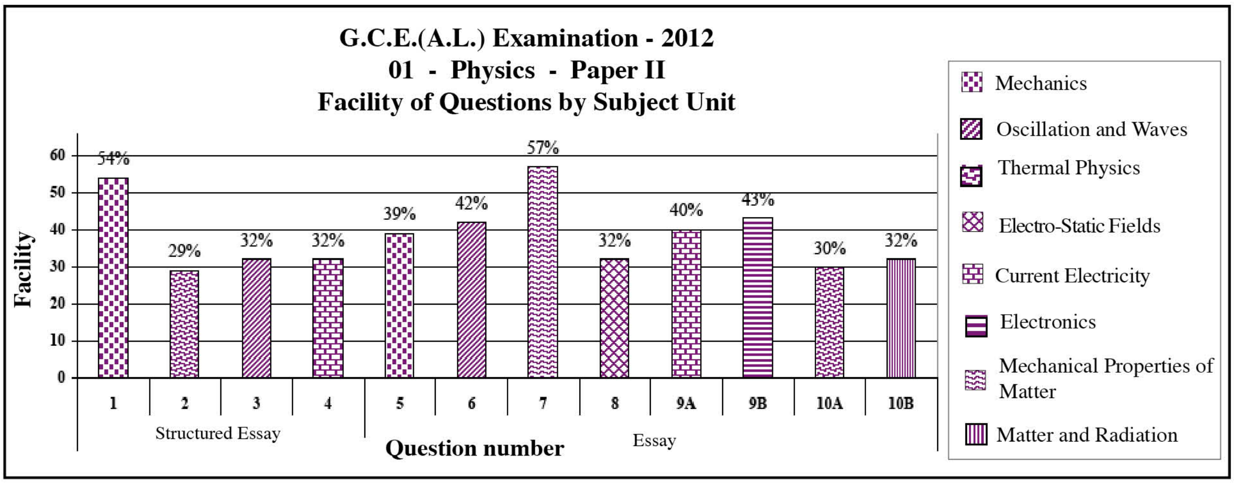
But the Facility of the sub-parts (*b*) (iii) and (*b*) (iv) are equal to a lower value such as 26%. The weakness of students in substituting values correctly in an expression derived from the sub-part (*b*) (ii) and simplifying the expression has caused the reduction of marks. To get the answer for the sub-part (*b*) (iv), it was needed to convert the equation $PV = nRT$ into the equation $PV = NkT$ according to given data. Students' failure for this conversion of the equation has caused to lower their achievement level.

When the correct answer for the sub-part (*b*) (iv) was unable to be obtained, it is unable to score the mark allotted for the reasoning in the sub-part (*b*) (v). Therefore the facility of this part remains at a lower value of 13%.

The sub-part (*b*) (vi) of this question has the least value of 4%. It was expected to obtain an expression for T'', taking that $\lambda = \dfrac{h}{\sqrt{3mkT'}}$ in sub-part (*b*) (ii), $a = \sqrt[3]{\dfrac{kT'}{10^5}}$ in (*b*) (iv) and $\lambda = a$ according to given information in (*b*) (vi). However due to the reasons such as incorrect use of T', neglecting the equivalence of expressions, failure to simplify the expressions, the facility of this sub-part has remained at a minimum value of 4%. Students have shown weaknesses in reaching the final answer since they have not used in calculations the given values in the question which make the simplifications easier.

The teachers are expected to guide students to read the questions carefully, identify the given data, correctly substitute the equations correctly and obtain the simplified answer for this type of questions based on similar subject areas in Physics.

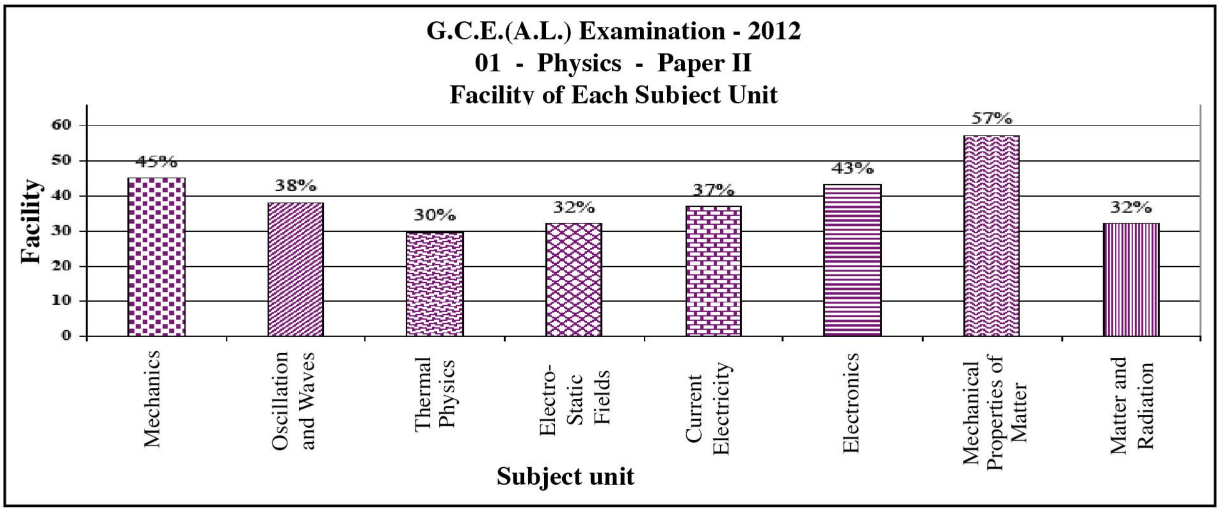
2.2.3 Overall observations, conclusions and suggestions regarding the answers to paper II



The facility of each of the questions in question paper II taken a value between 29% and 57%. Out of those questions, only the first question in structured essay type part and the seventh question in essay type part have Facility greater than 50%. Hence, the question in paper II do not seem to be so easy or difficult to the students.

Both of the question number 2 in structured easy part and number 10(A) in essay part which are set based on the unit 'Thermal Physics' have the minimum Facility of 29% and 30% respectively.

Though the question 1 which is based on the unit 'Mechanics' has the maximum facility, out of the four question in structured essay part (Part A) but the question 7 which is based on the unit 'Mechanical Properties of Matter' has the minimum facility out of the question in essay part (part B). The respective Facility of these two questions are 54% and 57% respectively.



When the total facility of each of the units in paper II is taken with account, the unit 'Mechanical Properties of Matter' has the maximum facility of 57% and the only question set within this unit is question 7. The unit 'Thermal Physics' has the minimum facility of 30% and the question 2 and 10 A have been set within this unit.

It is necessary to pay more attention on the unit 'Thermal Physics' in the teaching - learning process. The fact that the two questions set within this unit having the lowest marks (minimum facility indices) implies that the students' performance in experiments and related calculations which come under the unit 'Thermal Physics' is insufficient.

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 period of time allocated and the amount of marks allotted must be taken into account and before selecting the questions, these things should be clearly read and understood.
* For each of the questions in paper I, only one most appropriate answer must be selected and only one cross must be marked clearly on the answer sheet.
* The answers for each major question of paper II must be started at the top of a new page.
* Answers must be in clear hand writing.
* Index Number of the candidate must be written at the relevant place of each page.
* The Number of Question, its parts and the sub-part must be indicated accurately.
* Extensive answers must not be given where precise answers are expected and also short answers are not sufficient where descriptive answers are expected.
* The facts must be submitted logically and analytically according to the form of the question.
* In answering the paper II, all the parts and subparts of the major question must be well read and only the targeted answer for each sub-part must be written down.
* It is necessary to be accountable 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. Only Black or Blue pens are allowed.

Special instructions :

* The numerical values given in the questions must be used to make the simplifications of the calculations easy.
* Diagrams must be very clearly drawn and labelled where ever necessary.
* The steps of calculations must be clearly given in the sequential order.
* The units where ever necessary must be used accurately.
* When ray-diagrams (in optics) are drawn, the directions must be indicated using arrow-heads.
* In graphs , the axes x and y must be labelled accurately and the units also must be given where ever necessary.

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.
- When the style of answering the question papers in G. C. E. (Advanced Level) Examination is taken into account, it can be concluded that students' understanding of the subject Physics is insufficient. Since the principles and concepts have not been correctly formed, the weakness of inability to understand the questions accurately is to be seen. If the scientific method is appropriately used in the teaching learning process in the classroom, students can gain a lot of competencies.
- The students must conduct all the experiments which are recommended to be performed in the physics laboratory individually or in groups and collect experiences themselves. As the alternative instruments apparatus can be supplied for most of the experiments easily, the students must be provided with opportunities to perform experiments in the laboratories using those alternative equipment.
- Students can be easily motivated to reach the expected targets by getting them involved in laboratory tests in the learning teaching process.
- It is more appropriate 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.

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