G.C.E.(A.L.) Examination - 2015

Evaluation Report

01 - Physics

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

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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. New Syllabus in the year 2015, 210340 school candidates and 44851 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 2015 and information about the candidates' responses to them. It encompasses expected answers for the questions of papers I and II, the mark scheme, 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, and the TSEP-WB that provided financial assistance for this task.

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

29th June 2016
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 the technological world.

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

3. develops abilities and skills that are relevant to the 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	49226	12481	61707
Tamil	8501	1580	10081
English	2798	601	3399
Total	**60525**	**14662**	**75187**

Table 1

1.2.2 Grades obtained by the candidates

Grade	School Candidates		Private Candidates		Total	Percentage
	Number	Percentage	Number	Percentage		
A	1786	2.95	378	2.58	2164	2.88
B	4292	7.09	1256	8.57	5548	7.38
C	10980	18.14	2934	20.01	13914	18.51
S	22616	37.37	5563	37.94	28179	37.48
F	20851	34.45	4531	30.90	25382	33.76
Total	**60525**	**100.00**	**14662**	**100.00**	**75187**	**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	5879	297	5.05	491	8.35	1243	21.14	2134	36.30	4165	70.85	1714	29.15
2. Gampaha	3369	80	2.37	171	5.08	535	15.88	1259	37.37	2045	60.70	1324	39.30
3. Kalutara	2092	26	1.24	87	4.16	255	12.19	806	38.53	1174	56.12	918	43.88
4. Kandy	2609	74	2.84	157	6.02	438	16.79	994	38.10	1663	63.74	946	36.26
5. Matale	660	3	0.45	21	3.18	89	13.48	242	36.67	355	53.79	305	46.21
6. Nuwara Eliya	798	10	1.25	24	3.01	105	13.16	272	34.09	411	51.50	387	48.50
7. Galle	2474	64	2.59	130	5.25	352	14.23	820	33.14	1366	55.21	1108	44.79
8. Matara	1942	43	2.21	99	5.10	258	13.29	718	36.97	1118	57.57	824	42.43
9. Hambantota	1428	13	0.91	58	4.06	180	12.61	531	37.18	782	54.76	646	45.24
10. Jaffna	1230	54	4.39	103	8.37	234	19.02	461	37.48	852	69.27	378	30.73
11. Kilinochchi	146	0	0.00	8	5.48	17	11.64	56	38.36	81	55.48	65	44.52
12. Mannar	166	2	1.20	2	1.20	18	10.84	65	39.16	87	52.41	79	47.59
13. Vavuniya	280	10	3.57	12	4.29	42	15.00	107	38.21	171	61.07	109	38.93
14. Mullativu	158	0	0.00	3	1.90	9	5.70	52	32.91	64	40.51	94	59.49
15. Batticaloa	652	27	4.14	36	5.52	132	20.25	265	40.64	460	70.55	192	29.45
16. Ampara	1016	17	1.67	38	3.74	148	14.57	343	33.76	546	53.74	470	46.26
17. Trincomalee	470	12	2.55	28	5.96	66	14.04	160	34.04	266	56.60	204	43.40
18. Kurunegala	2740	44	1.61	113	4.12	342	12.48	1002	36.57	1501	54.78	1239	45.22
19. Puttalam	941	16	1.70	42	4.46	124	13.18	342	36.34	524	55.69	417	44.31
20. Anuradhapura	1290	21	1.63	49	3.80	169	13.10	422	32.71	661	51.24	629	48.76
21. Polonnaruwa	476	7	1.47	15	3.15	51	10.71	144	30.25	217	45.59	259	54.41
22. Badulla	1390	25	1.80	59	4.24	185	13.31	498	35.83	767	55.18	623	44.82
23. Monaragala	646	4	0.62	13	2.01	60	9.29	221	34.21	298	46.13	348	53.87
24. Ratnapura	1597	23	1.44	61	3.82	215	13.46	583	36.51	882	55.23	715	44.77
25. Kegalle	1426	18	1.26	54	3.79	208	14.59	540	37.87	820	57.50	606	42.50
All Island	**35875**	**890**	**2.48**	**1874**	**5.22**	**5475**	**15.26**	**13037**	**36.34**	**21276**	**59.31**	**14599**	**40.69**

Table 3

1.2.4 Marks obtained according to class intervals

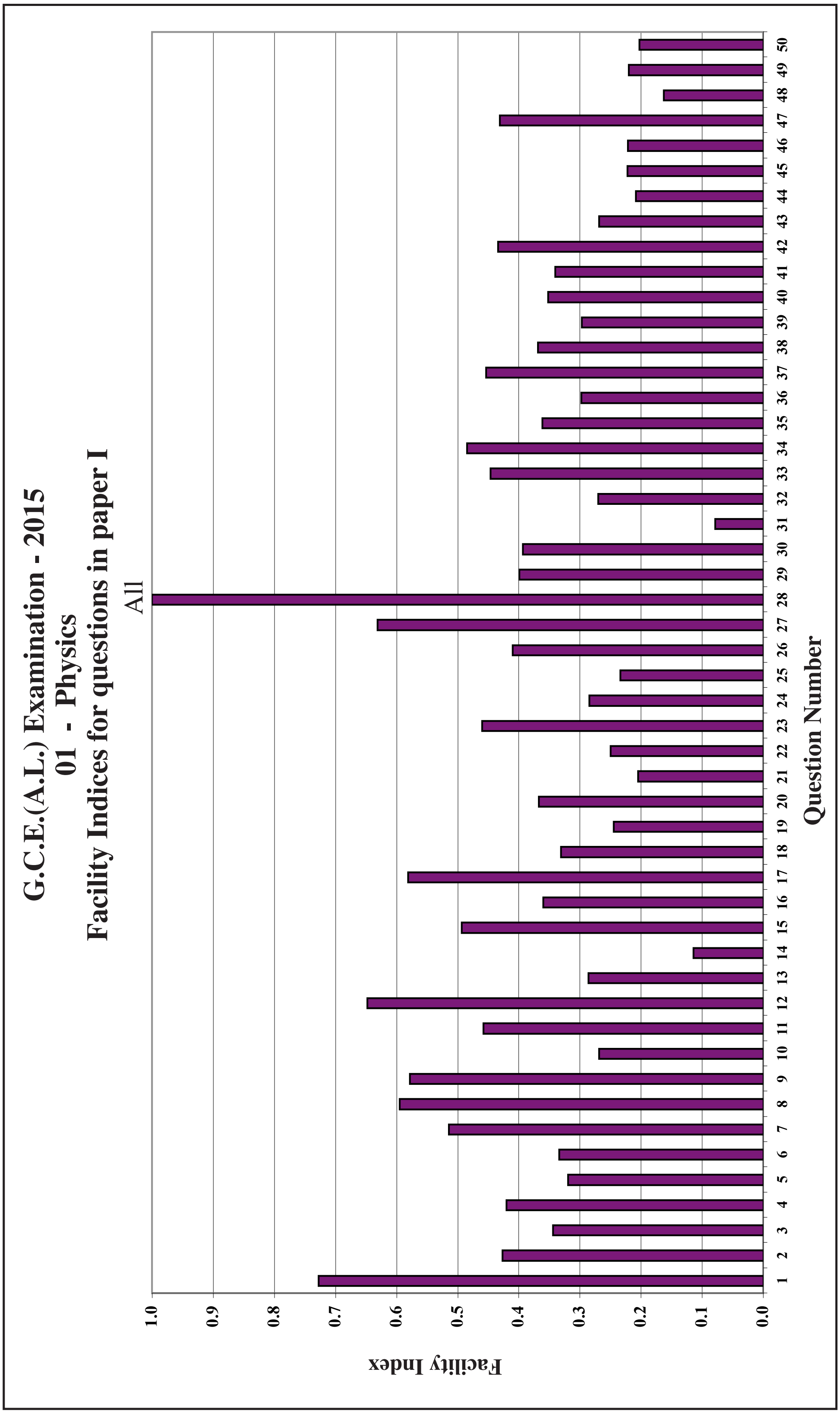
Class Interval	Frequency	Frequency Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91 - 100	1	0.00	75187	100.00
81 - 90	76	0.10	75186	100.00
71 - 80	1026	1.36	75110	99.90
61 - 70	3967	5.28	74084	98.53
51 - 60	8049	10.71	70117	93.26
41 - 50	13117	17.45	62068	82.55
31 - 40	19239	25.59	48951	65.11
21 - 30	20305	27.01	29712	39.52
11 - 20	9122	12.13	9407	12.51
01 - 10	283	0.38	285	0.38
00 - 00	2	0.00	2	0.00

Table 4

Table 4 shows the distribution of marks of candidates in each class interval. For an example, number of candidates who obtained marks in 31 – 40 class interval is 19239. It is 25.59% of the total number of candidates who sat for this subject. The cumulative frequency of this class interval is 48951. That means the number of candidates who have obtained 40 or less than 40 mark is 48951. It is 65.11%, of the total number of candidates.

1.3 Analysis of Subject Achievement

1.3.1 Achievement for Paper I

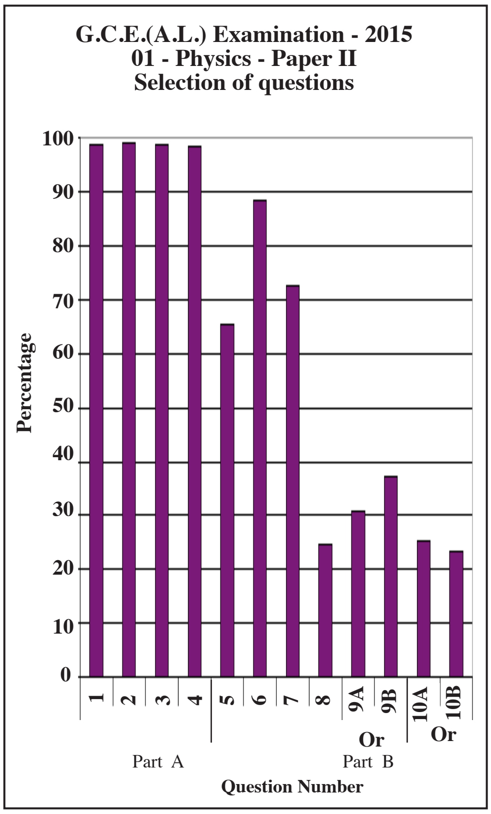


Graph 1 (prepared by the data obtained from RD/16/05/AL form)

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

Eg: A highest number of candidates have answered correctly for the question number 1. The facility index of that question is 73%.
A least number of candidates have answered correctly for the question number 31. The facility index of that question is 8%.

1.3.2 Selection of questions in paper II

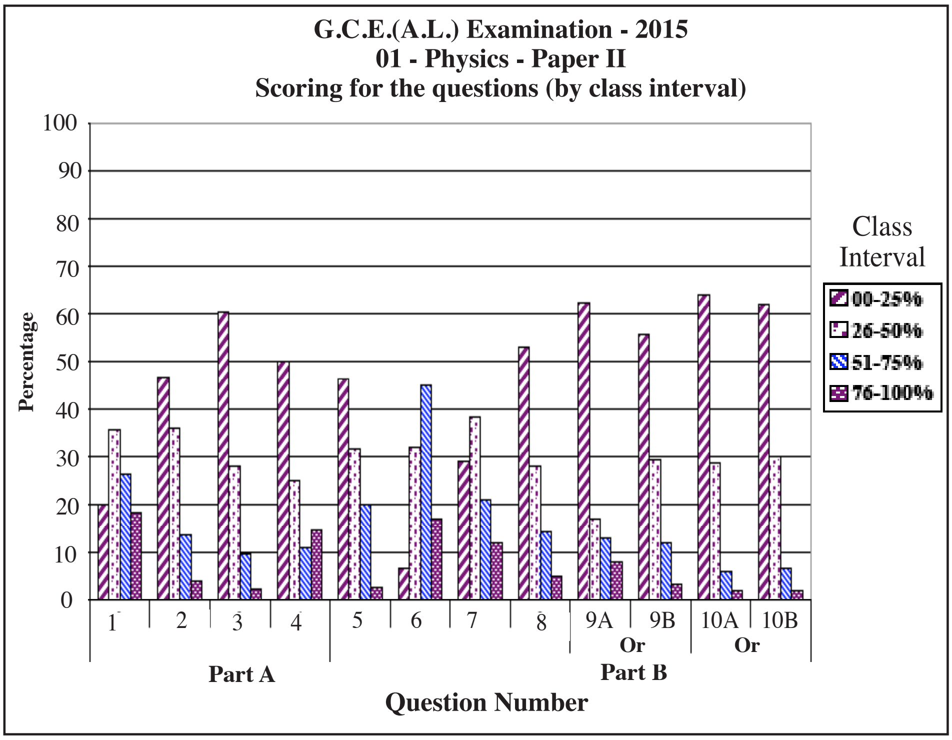


Graph 2 (Prepared using the information collected from the form RD/16/02/AL)

This graph shows the percentage of student who have selected questions from paper II. Although questions 1 to 4 are compulsory, a small number of students have not answered them. Only 98% of the candidates have answered those questions.

A highest number of students have selected question number 6 out of the questions from 5 -10, and a least number of students have answered question number 10(B). The respective percentages are 88% and 24%.

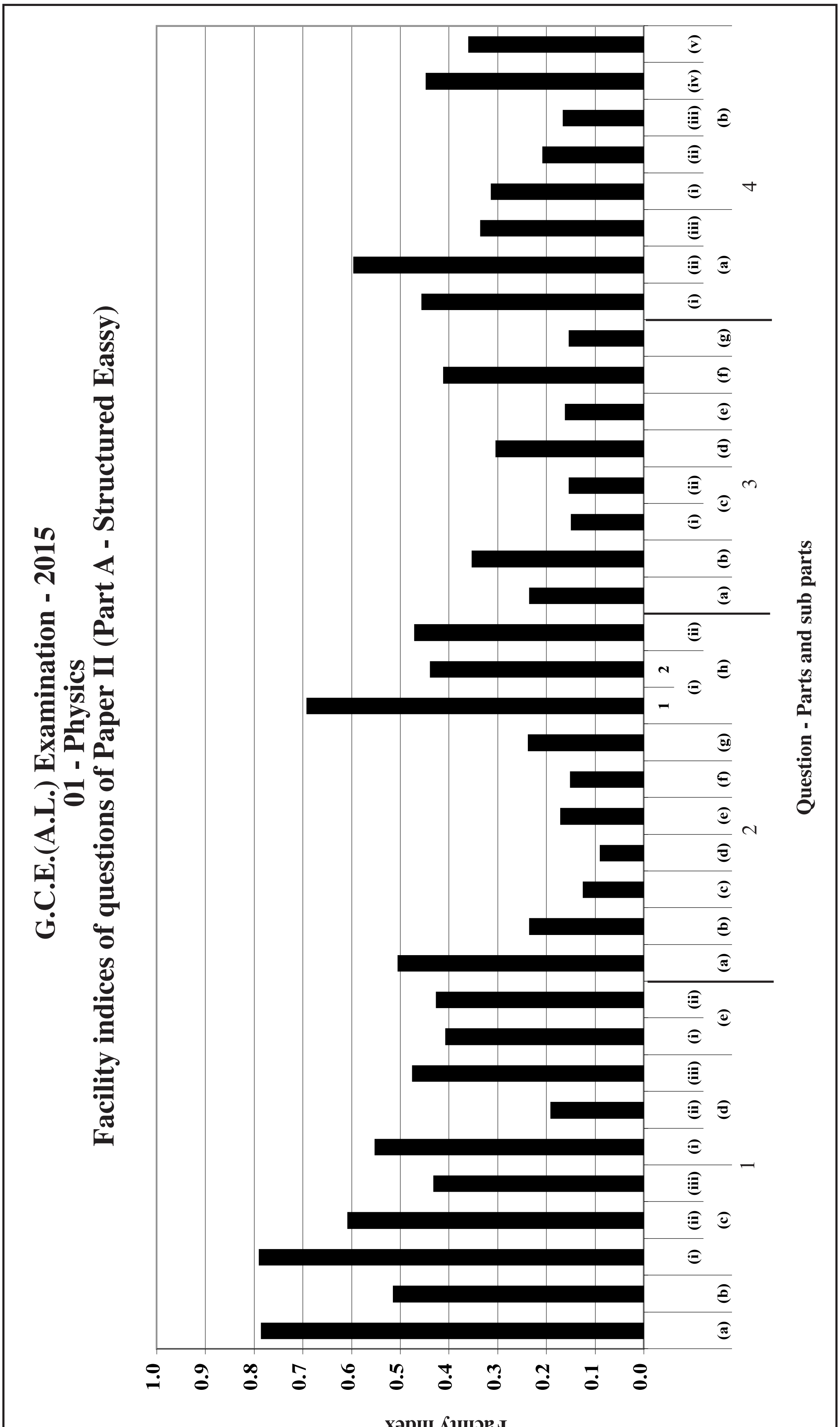
1.3.3 Scoring for the questions in paper II



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

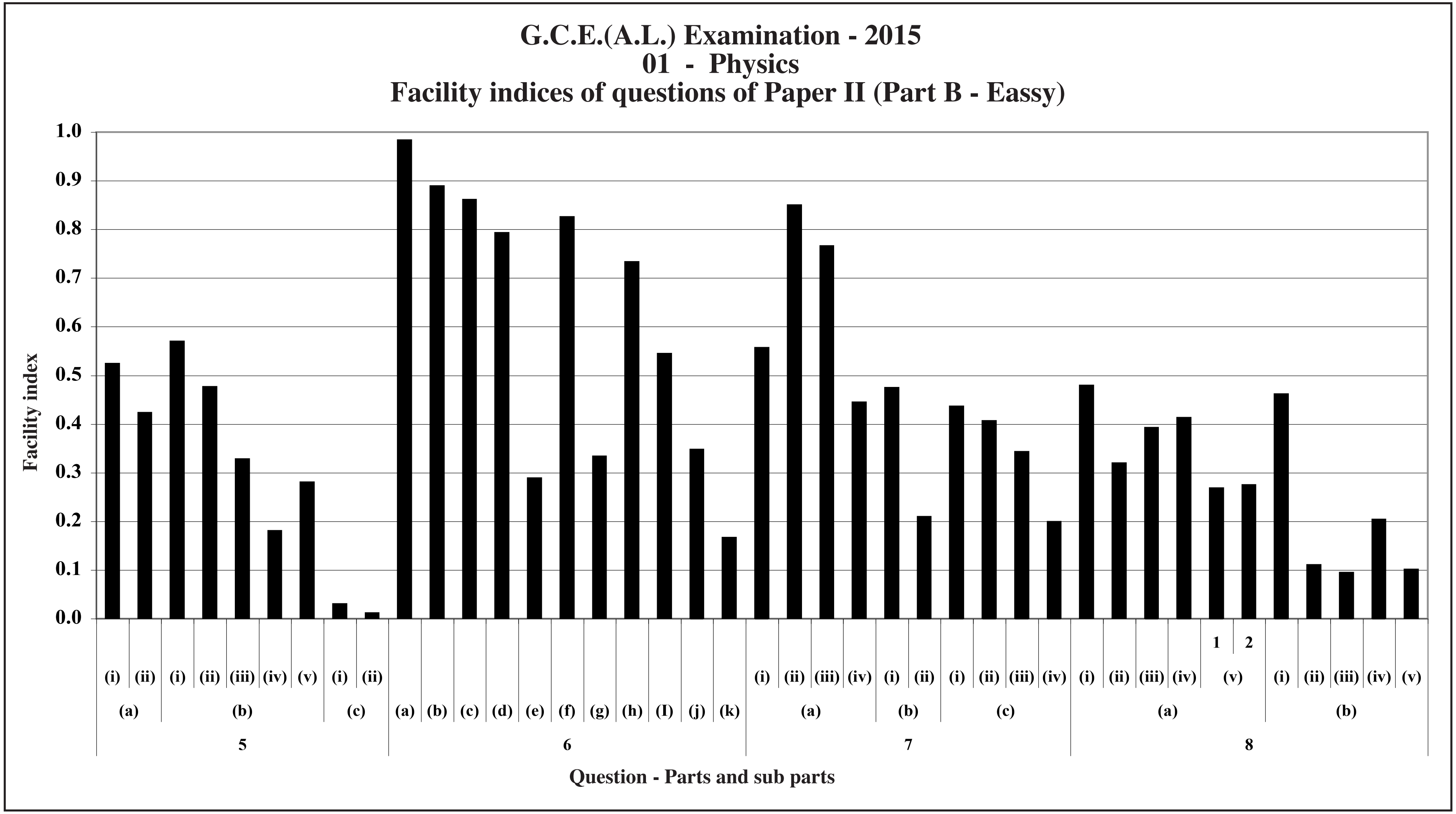
The marks allocated for question number 1 is 10. The percentage of students who have obtained 76% -100% of that marks, that is 8 - 10 mark is 18%. Also the percentage of students who have obtained 00%-25% of the marks that is 0 - 20 is 20%.

1.3.4 Achievement for Paper II



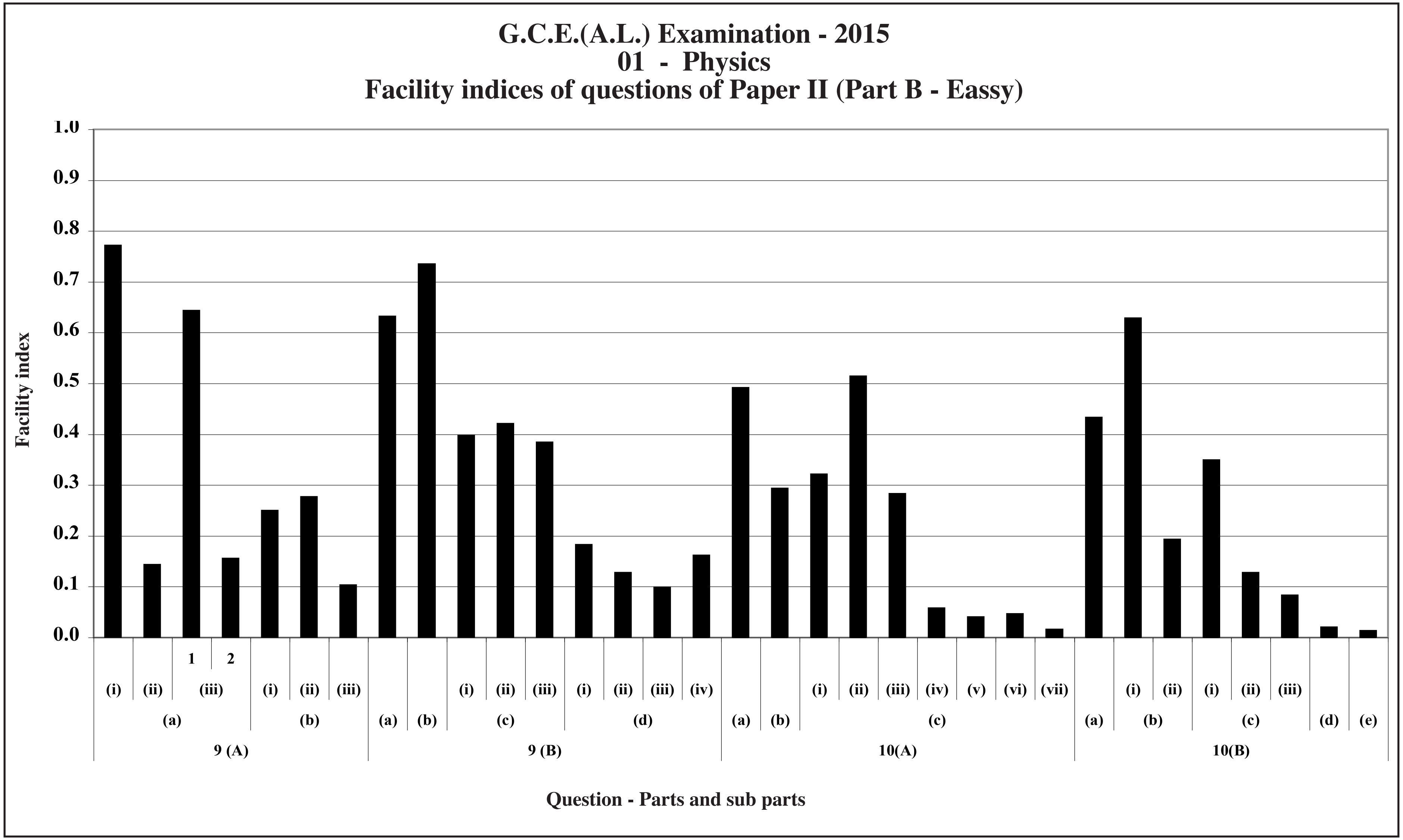
Graph 4.1 (Prepared using the information collected from the form RD/16/04/AL)

This graph shows the facility indexof each part of each question in Part A (Structured Essay) in paper II. For example the facility index of the *d*(i) of the question number 1, is 55 % and facility index of the part *e*(ii) is 43 %.



Graph 4.2

The graph of the facility indices for each sub parts of questions 5 - 8 in Part B (Essay) of the paper II.



Graph 4.3

The graph of the facility indices for each sub parts of questions 9(A) - 10 (B) in Part B (Essay) of the paper II.

Part II

2. Information on questions and answering

2.1 Question paper I and information on answering to paper I

2.1.1 Structure of the question paper I

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

2.1.2. Paper I

1. Electron volt (eV) is a unit of

(1) charge. (2) potential. (3) capacitance.
(4) energy. (5) electric field intensity.

2. The following measurements A, B and C have been taken using correctly selected measuring instruments.

$$A = 3.1 \text{ cm} \qquad B = 4.23 \text{ cm} \qquad C = 0.354 \text{ cm}$$

Instruments used for the measurements A, B and C are

	A	*B*	*C*
(1)	Vernier calliper	Vernier calliper	Micrometer screw gauge
(2)	Metre ruler	Metre ruler	Vernier calliper
(3)	Metre ruler	Micrometer screw gauge	Travelling microscope
(4)	Metre ruler	Vernier calliper	Micrometer screw gauge
(5)	Vernier calliper	Metre ruler	Travelling microscope

3. Radii of capillary tubes of two mercury-in-glass thermometers A and B having equal volumes of mercury inside their bulbs are r and $\frac{r}{3}$ respectively. When the temperatures of the bulbs are increased by 1 °C, the ratio

$$\frac{\text{Change in length of mercury column in } A}{\text{Change in length of mercury column in } B}$$ is approximately (Neglect the expansion of glass)

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

4. By what factor does the sound intensity increase if the sound intensity level increases by 1 dB?

(1) 1 (2) $10^{0.1}$ (3) 10^{1} (4) 10^{10} (5) 10^{12}

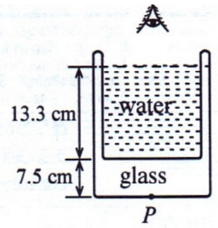
5. Consider the following statements made regarding three optical instruments.

(A) Simple microscope has a single convex lens, and when in normal adjustment, the microscope produces a virtual image at the least distance of distinct vision.
(B) Compound microscope has two convex lenses, and when in normal adjustment, the microscope produces a virtual magnified image at infinity.
(C) Astronomical telescope has two convex lenses, and when in normal adjustment, the telescope produces a real magnified image at infinity.

Of the above statements,

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

6. A cylindrical glass vessel with a 7.5 cm thick bottom, is filled with water up to a height of 13.3 cm as shown in the figure. Refractive indices of glass and water are 1.5 and 1.33 respectively. The apparent depth of a mark located at point P of the bottom of the vessel when observed from above the water surface is



(1) 5.8 cm (2) 10.9 cm (3) 11.6 cm
(4) 11.9 cm (5) 15.0 cm

7. A bull fastened to a strong tree with a rope attempting to eat a nearby coconut plant is shown in figure (a). The free-body diagram for the bull is correctly represented by

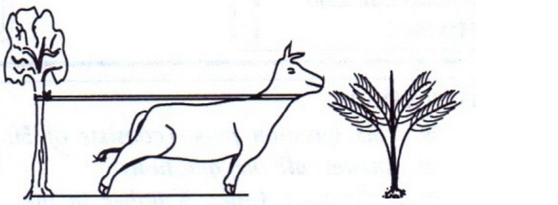
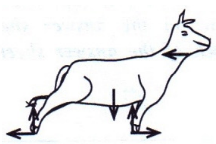
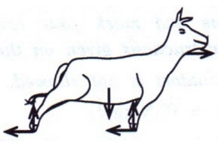
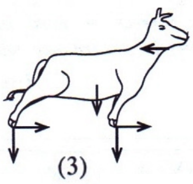
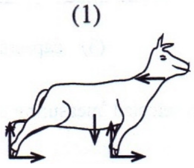


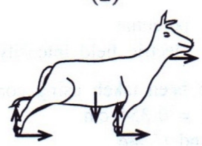
Figure (a)


(1)

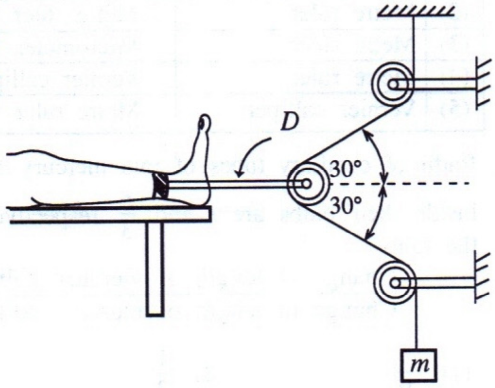

(2)


(3)


(4)


(5)

8. The pulley arrangement shown in the figure exerts a force on a leg of a patient connected to a traction device D. The pulleys are frictionless and the system is at equilibrium. If the horizontal force acting on the leg by D is 80 N, then the value of the hanging mass m will be $\left(\cos 30° = \frac{\sqrt{3}}{2}\right)$



(1) $\frac{4}{\sqrt{3}}$ kg (2) 4 kg

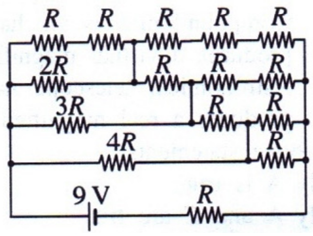
(3) $\frac{8}{\sqrt{3}}$ kg (4) 8 kg

(5) $8\sqrt{2}$ kg

9. If a 1 F air-filled parallel plate capacitor is made by using two metal sheets, each of area A separated by 0.9 cm, the area A would be (Take ε_0 as 9×10^{-12} F m^{-1})

(1) 1 cm^2 (2) 100 cm^2 (3) 1 000 m^2 (4) 100 km^2 (5) 1 000 km^2

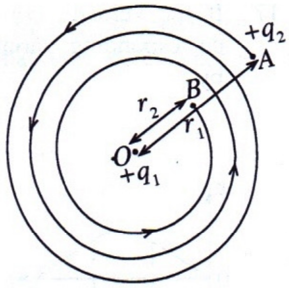
10. Current (in Amperes) drawn from the battery in the given circuit is



(1) $\frac{1}{R}$ (2) $\frac{2}{R}$ (3) $\frac{3}{R}$

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

11. A point charge of $+q_1$, is held at a point O. The points A and B are located at distances r_1 and r_2 from O respectively. The work done in bringing another point charge of $+q_2$ from the point A to point B along a spiral path of length l as shown in the figure is



(1) $\frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$ (2) $\frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right) l$

(3) $\frac{q_1}{4\pi\varepsilon_0}\left(\frac{q_1 - q_2}{r_2^2 - r_1^2}\right) l$ (4) $\frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} + \frac{1}{r_1}\right)$

(5) $\frac{q_1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_2^2} - \frac{q_2}{r_1^2}\right) l$

12. Variation of the displacement (x) with time (t) for a particle executing a simple harmonic motion over a period (T) is shown in figure (a). The variation of the kinetic energy (K) of the particle with time (t) over the period is best represented by

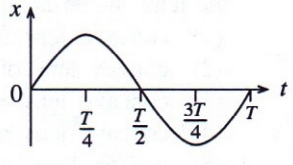
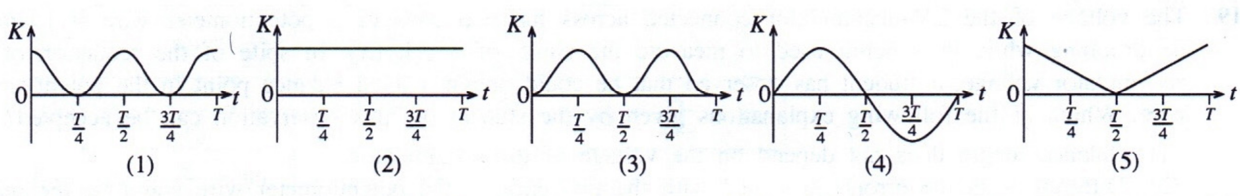


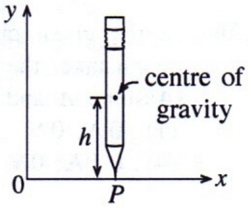
Figure (a)

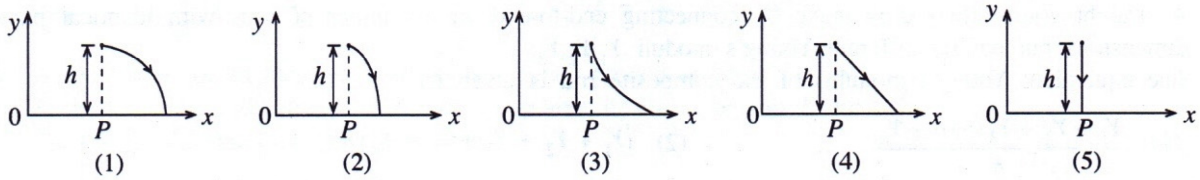


13. A ball is dropped from a height of 1.8 m onto a rigid surface. The collision between the ball and the surface is perfectly elastic. If the ball continues to bounce on the surface, the motion of the ball is

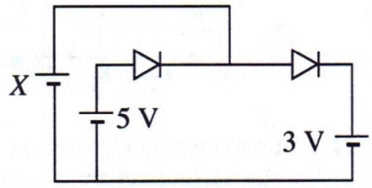
(1) simple harmonic with a period of 1.2 s.
(2) not simple harmonic but periodic with a period of 0.6 s.
(3) not simple harmonic but periodic with a period of 1.2 s.
(4) simple harmonic with a period of 0.6 s.
(5) simple harmonic with a period of 2.4 s.

14. A pencil is held vertical on its tip on a frictionless table as shown in the figure. When it is allowed to fall freely towards the $+x$-direction, the path of the centre of gravity of the pencil is best represented by.





15. In the circuit shown, each of the rectifier diodes requires a voltage of 1 V across it to make it forward biased. In order to make both diodes forward biased, the voltage of the battery X should be



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

16. A, B and C are three metals with threshold wavelengths $\lambda_A = 0.30\ \mu m$, $\lambda_B = 0.28\ \mu m$ and $\lambda_C = 0.20\ \mu m$ respectively for photoelectric emission. Photons of frequency 1.2×10^{15} Hz are incident on each of the metals. Photoelectrons are emitted (The speed of light in vacuum is 3×10^8 m s^{-1}.)

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

17. If the velocity (v) of an object varies with time (t) as shown in figure (a), the corresponding variation of the displacement (x) with time (t) is best represented by

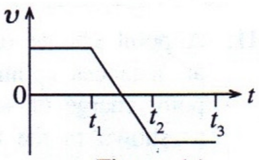
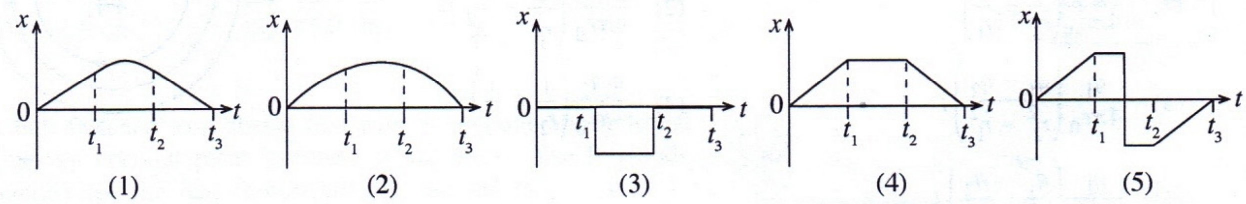


Figure (a)



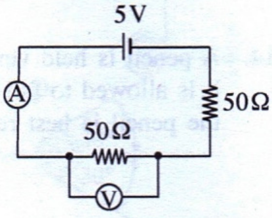
18. When a small object is placed 30 cm in front of a thin lens L_1 of focal length 10 cm, an image is formed behind the lens. When another thin lens L_2 is placed in contact with L_1, the image is formed at infinity. L_2 is a

(1) concave lens of focal length 15 cm.
(2) convex lens of focal length 15 cm.
(3) concave lens of focal length 20 cm.
(4) concave lens of focal length 10 cm.
(5) convex lens of focal length 20 cm.

19. The voltage of the 2V–accumulator connected across the two ends of a potentiometer wire is found to be dropping while it is being used to measure the e.m.f. of a cell (X). In spite of the reduction of the accumulator voltage, a student has observed that he could obtain a fixed balance point in the potentiometer wire. Which of the following explanations given by the student for this observation can be accepted?

(1) Balance length does not depend on the voltage of the accumulator.
(2) Differences in the errors associated with the two ends of the potentiometer wire could be the reason for achieving a fixed balance point.
(3) Though the voltage of the accumulator was reducing, the cell (X) had maintained a constant potential gradient across the wire.
(4) The increase of the temperature of the wire has nullified the effect of the reduction of the voltage of the accumulator.
(5) The voltage of the cell (X) too may have been dropping while conducting the experiment.

20. In the given circuit, if the voltmeter V and the ammeter A are interchanged by mistake, the respective readings of the ammeter and the voltmeter would be (Assume A and V to be ideal instruments.)



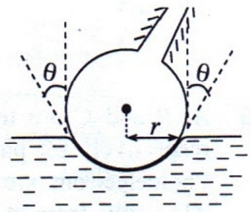
(1) 0 A, 0 V (2) 0 A, 5 V (3) 0 A, 2.5 V
(4) 0.1 A, 0 V (5) 0.05 A, 2.5 V

21. A straight composite rod is made by connecting end-to-end an n number of rods with identical physical dimensions but having different Young's moduli $Y_1, Y_2, Y_3, \ldots, Y_n$.
The equivalent Young's modulus of the composite rod is given by

(1) $\dfrac{Y_1 + Y_2 + Y_3 + \cdots + Y_n}{n}$ (2) $\left(Y_1 + Y_2 + Y_3 + \ldots + Y_n\right)n$

(3) $\dfrac{1}{\frac{1}{Y_1} + \frac{1}{Y_2} + \frac{1}{Y_3} + \cdots + \frac{1}{Y_n}}$ (4) $\dfrac{n}{\frac{1}{Y_1} + \frac{1}{Y_2} + \frac{1}{Y_3} + \cdots + \frac{1}{Y_n}}$ (5) $\left(Y_1 Y_2 Y_3 \cdots Y_n\right)^{\frac{1}{n}}$

22. Due to surface tension (0.07 N m^{-1}) of water, certain small insects are able to walk on water surfaces by pushing down the water surface. The feet of insects can be considered to be approximately spherical as shown in the figure. When an insect is stationary on a water surface, the position of a leg is shown in the figure. Radius of the circular cross-section of the spherical foot at the water level is r. The mass of the insect is 5.0×10^{-6} kg, and $r = 2.5 \times 10^{-5}$ m. If the weight of the insect is supported by its 6 legs, the value of $\cos\theta$ (see figure) is approximately (Take π as 3.)

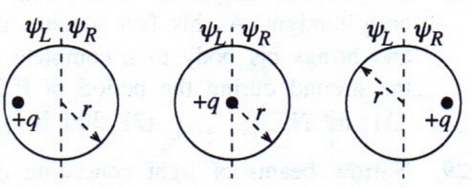


(1) 0.1 (2) 0.2 (3) 0.4 (4) 0.6 (5) 0.8

23. Paths of three charges moving separately in three uniform fields are shown in figures (A), (B) and (C). Which of the following responses correctly indicates the static electric field or magnetic field necessary to produce the paths shown?

	(A) 	(B)	(C) 
(1)	Electric field	Electric field	Electric field
(2)	Magnetic field	Magnetic field	Magnetic field
(3)	Electric field	Electric field	Magnetic field
(4)	Magnetic field	Magnetic field	Electric field
(5)	Magnetic field	Electric field	Electric field

24. Figures (A), (B) and (C) show three situations where a charge of $+q$ is surrounded by a spherical Gaussian surface of radius r. If ψ_L and ψ_R are the electric fluxes through the left and right hemispherical sections of the Gaussian surface respectively, which of the following is true regarding ψ_L and ψ_R?



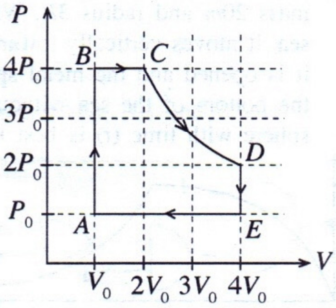
	(A)	(B)	(C)
(1)	$\psi_L = \psi_R = \dfrac{q}{2\varepsilon_0}$	$\psi_L = \psi_R = \dfrac{q}{2\varepsilon_0}$	$\psi_L = \psi_R = \dfrac{q}{2\varepsilon_0}$
(2)	$\psi_L > \dfrac{q}{2\varepsilon_0} > \psi_R$	$\psi_L = \psi_R = \dfrac{q}{2\varepsilon_0}$	$\psi_L < \dfrac{q}{2\varepsilon_0} < \psi_R$
(3)	$\psi_L > \dfrac{q}{\varepsilon_0} > \psi_R$	$\psi_L = \psi_R = \dfrac{q}{\varepsilon_0}$	$\psi_L < \dfrac{q}{\varepsilon_0} < \psi_R$
(4)	$\psi_L = \psi_R = \dfrac{q}{\varepsilon_0}$	$\psi_L = \psi_R = \dfrac{q}{\varepsilon_0}$	$\psi_L = \psi_R = \dfrac{q}{\varepsilon_0}$
(5)	$\psi_L < \dfrac{q}{2\varepsilon_0} < \psi_R$	$\psi_L = \psi_R = \dfrac{q}{2\varepsilon_0}$	$\psi_L > \dfrac{q}{2\varepsilon_0} > \psi_R$

25. An air-filled parallel plate capacitor of plate separation d is fully charged using a battery of voltage V_0. Then the battery is removed and the space between the plates of the capacitor is filled with a material of dielectric constant k. If the energy stored in the capacitor when it is filled with air is U_0, and the electric field intensity across the capacitor, and energy stored in the capacitor when it is filled with the dielectric material are E and U respectively, then

(1) $E = \frac{V_0}{d},\ U = kU_0$ (2) $E = \frac{V_0}{kd}, U = \frac{U_0}{k}$ (3) $E = \frac{V_0}{kd}, U = U_0$

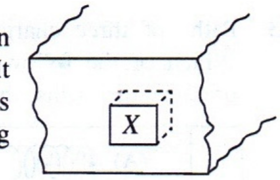
(4) $E = \frac{V_0}{kd}, U = kU_0$ (5) $E = \frac{V_0}{d},\ U = \frac{U_0}{k}$

26. A fixed mass of an ideal gas undergoes a cyclic process as shown in the P–V diagram. If the temperatures of the points A, B, C, D and E are T_A, T_B, T_C, T_D and T_E respectively, then,



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

27. Figure shows a part of an outdoor brick-structure with a cubical-shrine (X) carved in as shown. The shrine is lime plastered and the front is sealed with a sheet of glass. It has been seen very often that water vapour condenses on the inner surface of the glass sheet, and it is found to happen mostly during the evenings. Which of the following deductions made by a student about this situation is most **unlikely**?

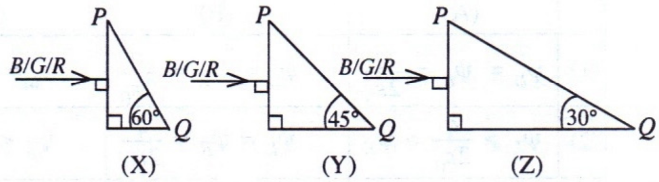


(1) Although the shrine is sealed from the front side, water vapour can enter the shrine from the bulk of the brick structure.
(2) Relative humidity at the vicinity of the inner surface of glass sheet varies during the course of the day.
(3) Atmospheric temperature has no effect on the condensation of water vapour.
(4) The bricks of the structure may have absorbed water during rainy seasons.
(5) Condensation of water vapour can be reduced, if the walls of the shrine are water proofed and front sealed during a dry season.

28. A gymnastic player of mass 50 kg lands on the ground vertically with a velocity of 6 m s^{-1} and with his body straight. As his feet touches the ground he bends his knees while keeping rest of the body vertical, and brings his body to a complete stop in 0.2 s. The average value of the force exerted on the player by the ground during the period of 0.2 s is

(1) 30 N (2) 300 N (3) 1 500 N (4) 1 800 N (5) 3 000 N

29. Narrow beams of light consisting of a mixture of three primary colours, blue (B), green (G) and red (R), are incident normally as shown in figures (X), (Y) and (Z) on different glass prisms made from the same material. The critical angles of the material of the prism for blue, green and red are 43°, 44° and 46° respectively. When viewed through the faces PQ, only red colour can be seen in



(X) (Y) (Z)

(1) X only. (2) Y only. (3) X and Y only. (4) X and Z only. (5) all X, Y and Z.

30. A wire of radius 1.0 mm made of a material of Young's modulus 4×10^{11} N m^{-2} is subjected to a tension of 30 N. The magnitude of the ratio $\frac{v_L}{v_T}$ of the longitudinal wave velocity (v_L) to transverse wave velocity (v_T) along the wire is (Take π to be 3.)

(1) 100 (2) 150 (3) 200 (4) 250 (5) 300

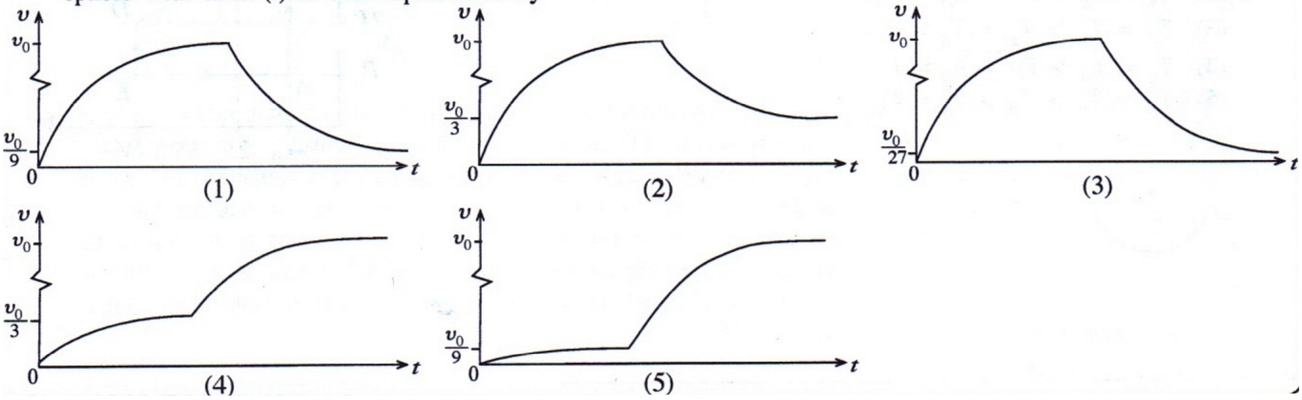
31. The following table shows the binding energies of some nuclei.

Nucleus	${}^{4}_{2}$He	${}^{20}_{10}$Ne	${}^{40}_{20}$Ca	${}^{60}_{28}$Ni	${}^{238}_{92}$U
Binding energy (MeV)	28.3	160.6	342.1	526.8	1802.0

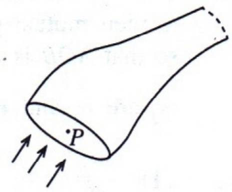
Which one of the above nuclei is the most stable nucleus?

(1) ${}^{4}_{2}$He (2) ${}^{20}_{10}$Ne (3) ${}^{40}_{20}$Ca (4) ${}^{60}_{28}$Ni (5) ${}^{238}_{92}$U

32. Seven identical metal spheres each of radius R and mass m are packed inside a hollow spherical container of mass $20m$ and radius $3R$. When this container is released from rest from the water surface of a calm, deep sea, it moves vertically towards the bottom of the sea. Once the container has reached its terminal velocity v_0, it is opened and the metal spheres are allowed to continue their motion vertically and independently towards the bottom of the sea without any influence from the container. The variation of the velocity (v) of a metal sphere with time (t) is best represented by



33. Figure shows a flow tube corresponding to a streamline motion of a non-viscous and incompressible fluid. Which of the following statements is **not true** with regard to the fluid flow in such a tube?



(1) All particles entering at point P move along the same path in the tube.
(2) Flow velocity at a given point in the tube may vary with time.
(3) Particles moving along a given streamline may have different velocities at different points in the flow tube.
(4) Tangent drawn at any point of a streamline gives the direction of flow velocity at that point.
(5) Mass of fluid in the flow tube is always constant.

34. The variation of the angular acceleration (α) of a wheel of a motor vehicle starting from rest with time (t) is shown in figure (a). Variation of the angular velocity (ω) of the wheel with time (t) is best represented by

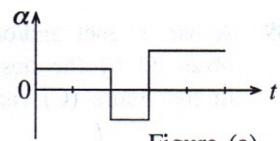
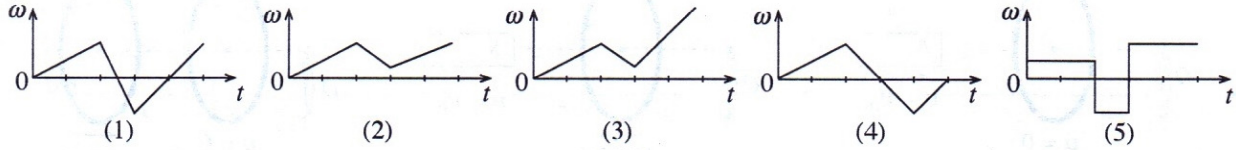
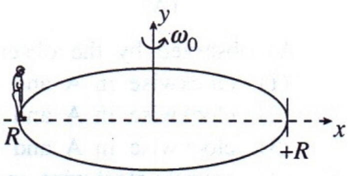
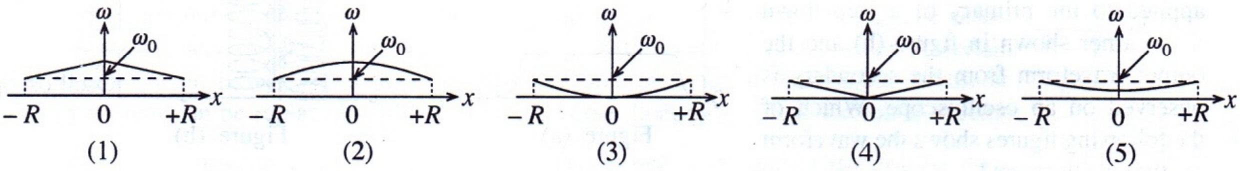


Figure (a)

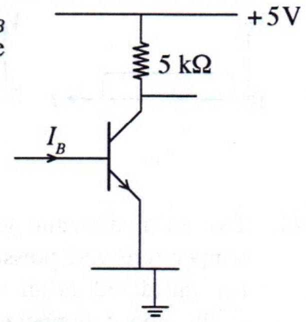


35. A child is standing at $x = -R$ of a horizontal merry-go-round of radius R in a carnival as shown in the figure. x–y is a coordinate system fixed to the merry-go-round with its y-axis along the axis of rotation. Using a driving motor, the merry-go-round is set in rotational motion with constant angular velocity ω_0 about its axis on a frictionless bearing, and subsequently allowed to **rotate freely** without the driving motor. Now if the child starts to move in the x-direction along the diameter of the merry-go-round to the location $x = +R$, the variation of the angular velocity (ω) of the merry-go-round with position (x) of the child is best represented by



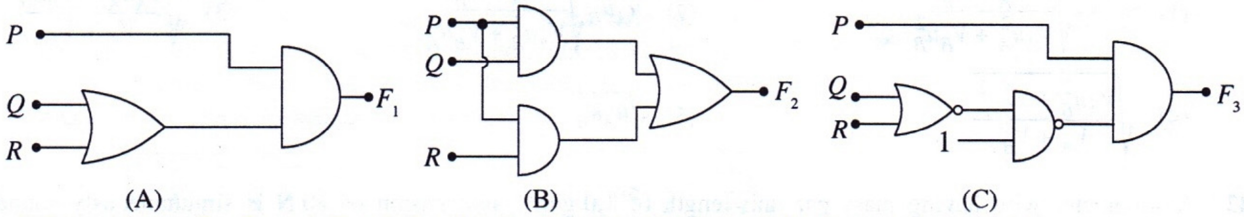


36. In the circuit shown, the current gain of the transistor is 100. When different I_B values are applied to the base, which of the following is true regarding the mode of operation of the transistor?



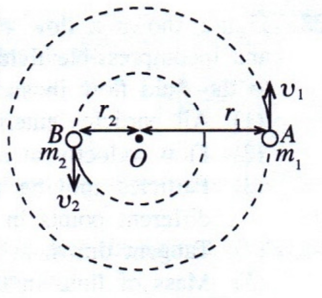
	I_B value applied in μA	Mode of operation of the transistor
(1)	0	Saturation mode
(2)	5	Cut off mode
(3)	12	Active mode
(4)	15	Cut off mode
(5)	20	Saturation mode

37. P, Q and R represent the binary input variables applied to the given circuits (A), (B) and (C).



When outputs F_1, F_2 and F_3 of the circuits for given input combinations are considered
(1) only A and B give the same output.
(2) only B and C give the same output.
(3) only A and C give the same output.
(4) all three circuits give the same output.
(5) all three circuits give different outputs.

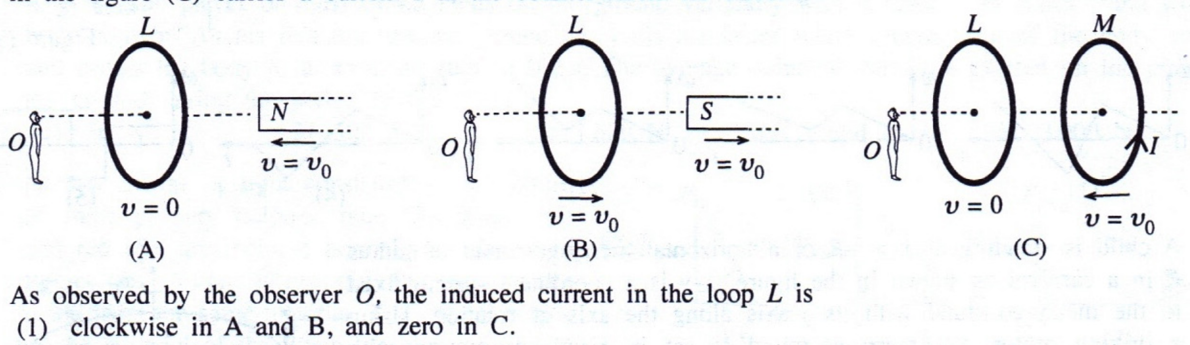
38. Two stars A and B of masses m_1 and m_2 respectively are in circular motions due to their mutual gravitational attraction, about the point O for which $m_1r_1 = m_2r_2$ so that AOB is always co-linear as shown in the figure. If the speeds of m_1 and m_2 are v_1 and v_2 respectively, the ratio $\frac{v_1}{v_2}$ is



(1) $\frac{m_2}{m_1}$ (2) $\frac{m_1}{m_2}$ (3) $\frac{m_2}{m_1 + m_2}$

(4) $\frac{m_1}{m_1 + m_2}$ (5) $\frac{m_1 + m_2}{m_2}$

39. A bar magnet and/or conducting loop/s are arranged separately as shown in figures (A), (B) and (C). As observed by the observer O, the magnet and the loop/s move with the velocities v as indicated. Loop M in the figure (C) carries a current I in the counter-clockwise direction.



As observed by the observer O, the induced current in the loop L is
(1) clockwise in A and B, and zero in C.
(2) clockwise in A and C, and zero in B.
(3) clockwise in A and C, and counter-clockwise in B.
(4) counter-clockwise in A and B, and zero in C.
(5) counter-clockwise in A and C, and zero in B.

40. Voltage waveform shown in figure (a) is applied to the primary of a step down transformer shown in figure (b) and the output waveform from the secondary is observed on an oscilloscope. Which of the following figures shows the waveform on the oscilloscope?

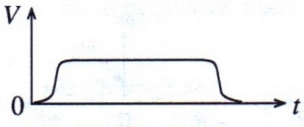


Figure (a)

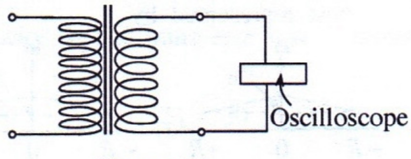
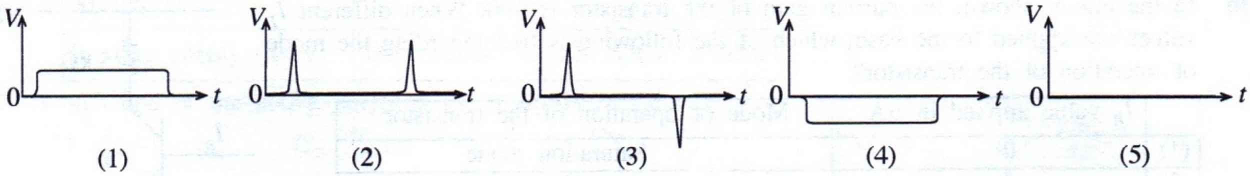


Figure (b)



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

41. Two ideal diatomic gases A and B of volumes V_A and V_B respectively with different densities at the same temperature and pressure are mixed together. The mixture is maintained at the above temperature and it can be considered as an ideal diatomic gas. If u_A and u_B are speeds of sound in gas A and gas B respectively at the above temperature and pressure, then the speed of sound in the mixture will be given by

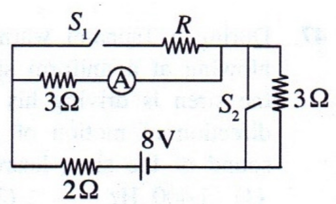
(1) $u_A u_B\sqrt{\dfrac{V_A + V_B}{V_A u_A^2 + V_B u_B^2}}$ (2) $u_A u_B\sqrt{\dfrac{V_A + V_B}{V_A u_B^2 + V_B u_A^2}}$ (3) $\sqrt{\dfrac{V_A u_A^2 + V_B u_B^2}{V_A + V_B}}$

(4) $\sqrt{\dfrac{V_A u_B^2 + V_B u_A^2}{V_A + V_B}}$ (5) $\sqrt{u_A u_B}$

42. A sonometer wire having mass per unit length of $1.0\ \mathrm{g\,m^{-1}}$ and tension of 40 N is simultaneously sounded with a tuning fork of frequency 320 Hz while varying its vibration length starting from a small value. In this process, if beats of frequency $5\ \mathrm{s^{-1}}$ can be observed on an oscilloscope, the corresponding vibration lengths (in m) of the sonometer wire are

(1) $\frac{2}{13}, \frac{10}{63}$ (2) $\frac{4}{13}, \frac{5}{8}$ (3) $\frac{4}{13}, \frac{20}{63}$ (4) $\frac{5}{8}, \frac{20}{63}$ (5) $\frac{10}{13}, \frac{4}{13}$

43. In the given circuit, the reading of the ammeter A indicates the same value when the switches S_1 and S_2 are both closed or both open. If A is an ideal ammeter, the value of the resistor R is

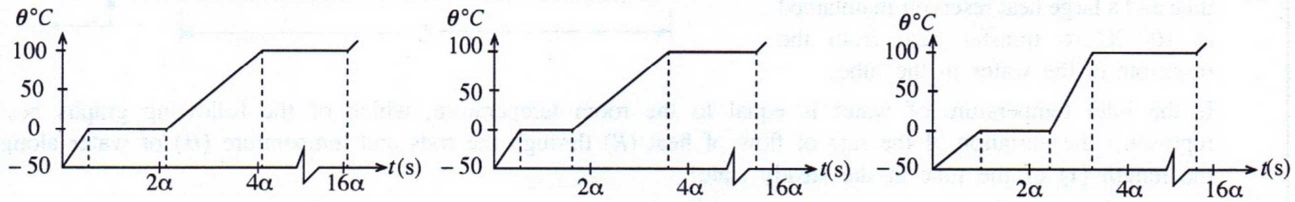


(1) 1 Ω (2) 2 Ω (3) 3 Ω
(4) 4 Ω (5) 6 Ω

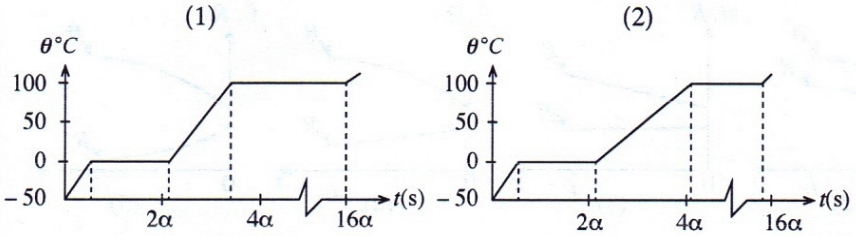
44. A piece of ice of mass 0.1 kg at –50 °C is heated uniformly by providing heat energy at a constant rate of 10 W. If the specific heat capacity of ice is α, in SI units, the values of the other relevant quantities in terms of α can be given approximately as follows.

Specific heat capacity of water	$= 2\alpha$
Latent heat of fusion of ice	$= 160\alpha$
Latent heat of vaporization of water	$= 1\,200\alpha$

Which of the following graphs best represents the variation of the temperature (θ) of the system with time (t)?

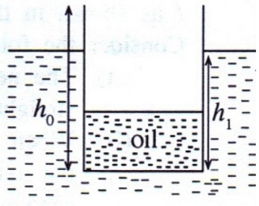


(1) (2) (3)



(4) (5)

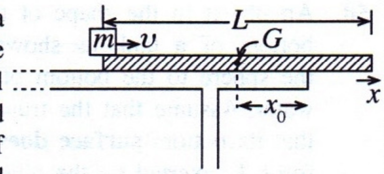
45. A vessel of uniform rectangular cross-section with height h_0 and mass M contains a certain amount of oil having mass m and density ρ_{oil} as shown in the figure. The vessel floats vertically in water of density ρ_ω ($> \rho_{oil}$) with height h_1 under water. A certain volume of oil is now replaced by an **equal** volume of water. If the maximum volume of oil that can be replaced while keeping the vessel floating is V and the initial volume of oil is V_0, then the ratio $\frac{V}{V_0}$ is given by (Assume that at the end of the process there is a certain amount of oil left in the vessel.)



(1) $\frac{(h_0 - h_1)(M + m)\rho_{oil}}{h_1 m(\rho_\omega - \rho_{oil})}$ (2) $\frac{h_0(M - m)\rho_{oil}}{h_1 m(\rho_\omega - \rho_{oil})}$ (3) $\frac{h_1}{h_o} \cdot \frac{\rho_\omega}{\rho_{oil}}$

(4) $\frac{(h_0 - h_1)(M - m)\rho_{oil}}{h_0 m(\rho_\omega + \rho_{oil})}$ (5) $\frac{h_0(M + m)\rho_{oil}}{M(h_0 + h_1)(\rho_\omega + \rho_{oil})}$

46. A uniform rectangular wooden strip of length L and mass M is placed on a table along the x direction and parallel to one of its edges so that a part of the strip is extended out as shown in the figure. Distance from the centre of gravity G of the strip to edge of the table is x_0. Now a small block of mass m is placed at the left edge of the strip, and an initial speed of v is given to it along the strip in the x direction. If the coefficient of kinetic friction between the strip and the block is μ, the minimum speed that can be given to the block to topple the strip is



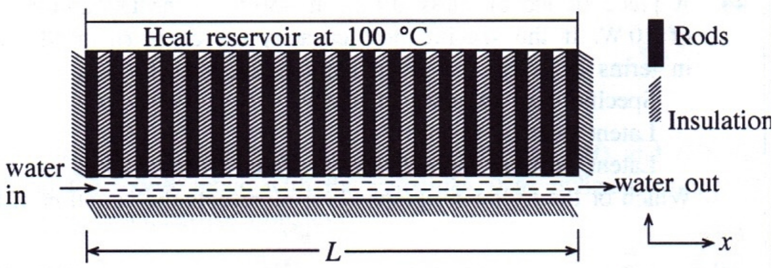
(1) $\sqrt{2\mu g\left(x_0 + \frac{L}{2} + \frac{Mx_0}{m}\right)}$ (2) $\sqrt{\mu g\left(\frac{L}{4} + \frac{Mx_0}{m}\right)}$

(3) $\sqrt{2\mu g\left(x_0 + \frac{L}{2} + \frac{mx_0}{M}\right)}$ (4) $\sqrt{\frac{\mu g M x_0 L}{\left(\frac{L}{2} + x_0\right)}}$ (5) $\sqrt{2\mu g\left(\frac{x_0}{2} + \frac{ML}{m}\right)}$

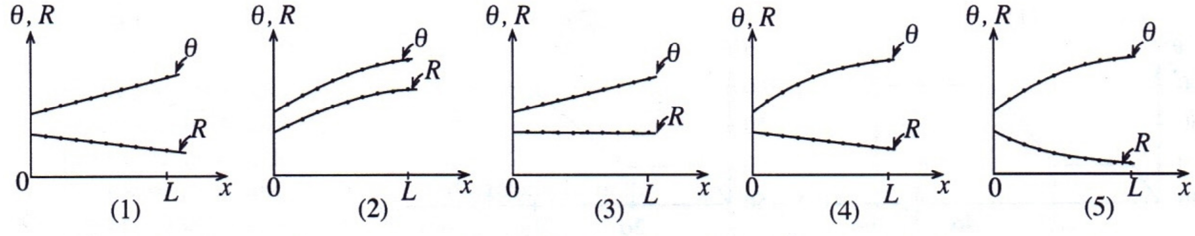
47. During a Tsunami warning, a stationary siren emits sound waves of frequency 1 600 Hz while a wind is blowing at a uniform speed of 60 m s^{-1} from the shore towards the land. A person hearing the sound of the siren is driving his car away from the shore towards the land at 30 m s^{-1}. If the wind blows in the direction of motion of the car and if the speed of sound in **still air** is 340 m s^{-1}, the frequency of the sound of the siren heard by the driver is

(1) 1 400 Hz (2) 1 480 Hz (3) 1 600 Hz (4) 1 740 Hz (5) 1 880 Hz

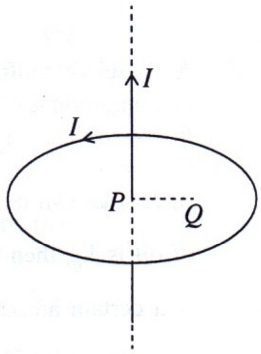
48. Water flows at a uniform rate through a tube of length L, which is made of an insulating material. A large number of identical, uniform and insulated metal rods which are equally spaced as shown in the figure is connected between the tube and a large heat reservoir maintained at 100 °C to transfer heat from the reservoir to the water in the tube.



If the inlet temperature of water is equal to the room temperature, which of the following graphs best represents the variation of the rate of flow of heat (R) through the rods and temperature (θ) of water along the length (x) of the tube at the steady state?



49. A long straight wire carrying a current I is held along the axis passing through the centre P and perpendicular to the plane of another circular loop carrying a current I as shown in the figure.



Consider the following statements.

(A) The net force and the net torque on the loop due to the current carrying straight wire are zero.

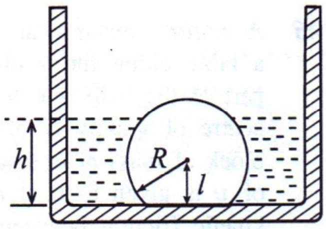
(B) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, there is a net torque on the loop due to the current carrying straight wire.

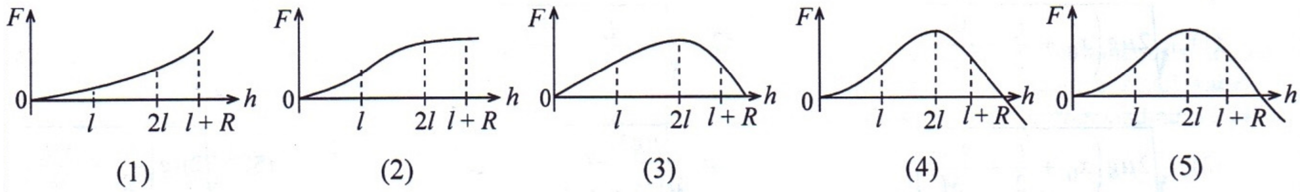
(C) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, the net force on the loop due to the current carrying straight wire is **not** zero.

Of the above statements,

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

50. An object in the shape of a truncated solid sphere of radius R is kept at the bottom of a tank as shown in the figure. The distance from the centre of the sphere to the bottom of the tank is l. The tank is now slowly filled with water. Assume that the truncated sphere is fixed to the bottom of the tank, so that its bottom **surface does not get wet**. The variation of the vertical upward force F, exerted on the object by the water, with the height h of water is best represented by





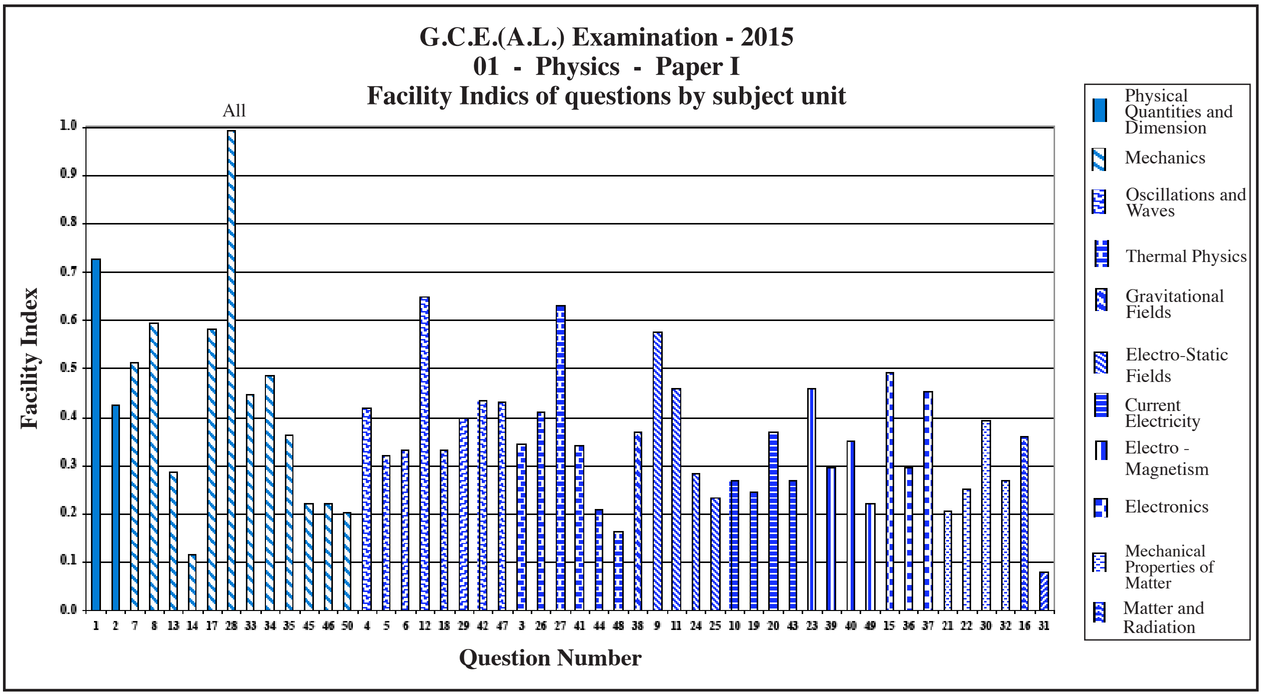
2.1.3. Expected answers and the scheme of marking

Scheme of Marking for Paper I

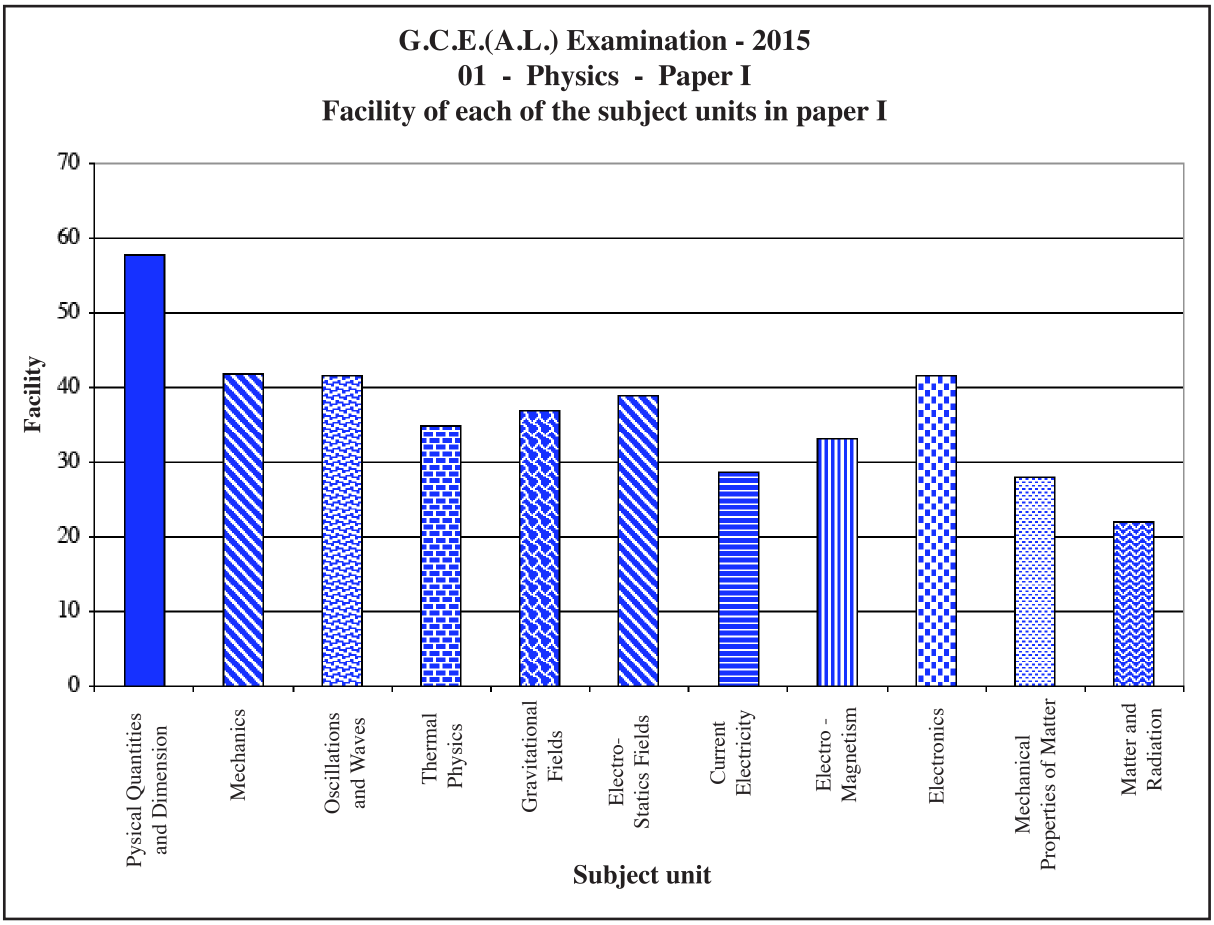
Question No.	Answer	Question No.	Answer
01.	4	26.	3
02.	4	27.	3
03.	1	28.	All
04.	2	29.	2
05.	1	30.	3
06.	5	31.	4
07.	4	32.	1
08.	3	33.	2
09.	5	34.	3
10.	4	35.	2
11.	1	36.	5
12.	1	37.	4
13.	3	38.	1
14.	5	39.	2
15.	4	40.	3
16.	4	41.	2
17.	1	42.	3
18.	1	43.	2
19.	5	44.	1
20.	2	45.	1
21.	4	46.	1
22.	5	47.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

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

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



Subject unit		Number of Questions	Highest facility		Lowest facility	
			Question	Facility	Question	Facility
1.	Physical Quantities and Dimension	2	1	73%	2	43%
2.	Mechanics	12	8	59%	14	11%
3.	Oscillations and Waves	8	12	65%	5	32%
4.	Thermal Physics	6	4	63%	48	16%
5.	Gravitational Fields	1	38	37%	-	-
6.	Electro-Static Fields	4	9	58%	25	23%
7.	Current Electricity	4	20	37%	19	24%
8.	Electro - Magnetism	4	23	46%	49	22%
9.	Electronics	3	15	49%	36	30%
	Mechanical Properties of Matter	4	30	39%	21	20%
11.	Matter and Radiation	2	16	36%	31	8%



The highest facility has been acquired by the unit Pysical Quantities and Dimension . Only 1 and 2 are the questions in paper I from that unit. The facility for question number 1 is 73% and for question number 2 is 8%.

There were 8 questions from the unit Oscillations and Waves. The facility for all those questions are in a range of 65% to 32%. Although the highest facility for the questions from unit Electronics is 49% the lowest facility is more than 30%. Therefore it shows the interest of the candidates for this unit.

The paper includes the highest number of questions, which are from mechanics. This paper includes 12 of highest number of questions from unit mechanics, 8 questions from Oscillations and Waves. These units are discussed initialy in the syllabus and although students allocate a long period of time, the highest facilities are 59% and 65%.

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

Question Number 1 is the, the question with the highest facility imdex in paper I. And also question number 12 and 27 have a facility greater than 60%. These questions have been prepared based on the fundamental principles and the accurate comprehension of those principles has brought the achievment of the students into a higher level. More than 50% of the students have selected the correct answer for question numbers 7, 8 and 9. The reasons for having a higher achievment level of the candidates for these questions is, that the answers for these questions can be obtained by using simple calculations and basic formulae.

Qustion Number 31 carries the lowest precentage of correct response. It is 8%. The reason is not knowing the subject matter in the syllabus although the candidates are supposed to know all.

Majority has failed to understand what is in the teachers' instructional manual clearly. It is compulsory to direct the attention of the students towards the analytical graph.

It is special that the percenage of students who selected answers (1) or (3) as the correct answer for question number 32 are equal. The reason for having a lower achievment level is, fail in understanding the density of small sphere and the combined sphere are equal and not indentifying that terminal velocity $V \alpha\ R^2$.

Although the questions 36 and 37 from eletronics are easy, the percentage of the candidates,who gave the correct responses is less than 50%. The reason is the reduation in achievement level of explaining the mode of the transistor interms of I_B and I_C. Therefore a due attention should be given to impart the knowledge of logic gates through practical applications for the students.

Only 21% of the candidates have selected the correct answer for question number 44. Though the answer can be obtained by calculating the time intervals the candidates have not reached the correct answer due to difficulties in mathematical knowledge. The same cause is applied for the question number 45 an 46 also.

There are 16% candidates who have selected correct answer for question number 48, which is a corresponding question for a past examination question regarding heat conductivity.

The achivment level can be increased for paper I by careful reading and understanding of the questions. The guidance of the teachers is essential in class room teaching and during practicals to understand how to explain the graphs and to mastering the exercises.

It is necessary to guide the students by using innovative technological equipment and theorical methodologies with examples to facilitate their understanding.

2.1.6 Selection of responses of each questions of the paper I (As a percentage)

Question Number	Correct Responses	Number of student selected each Response					
		1	2	3	4	5	Missing
1	4	10%	8%	3%	73%	6%	0
2	4	11%	7%	35%	43%	4%	0
3	1	34%	14%	8%	20%	23%	1
4	2	6%	42%	37%	8%	7%	0
5	1	32%	13%	35%	11%	8%	1
6	5	18%	14%	16%	18%	33%	1
7	4	15%	18%	6%	51%	10%	0
8	3	24%	8%	59%	6%	2%	1
9	5	4%	12%	14%	11%	58%	1
10	4	7%	12%	30%	27%	22%	2
11	1	46%	28%	6%	13%	7%	0
12	1	65%	7%	17%	5%	6%	0
13	3	16%	20%	29%	26%	8%	1
14	5	45%	21%	11%	12%	11%	0
15	4	10%	18%	12%	49%	10%	1
16	4	8%	8%	28%	36%	20%	0
17	1	58%	9%	7%	14%	11%	1
18	1	33%	27%	16%	11%	13%	0
19	5	13%	11%	38%	13%	24%	1
20	2	22%	37%	10%	15%	15%	1
21	4	34%	17%	23%	20%	5%	1
22	5	10%	18%	26%	20%	25%	1
23	5	2%	14%	15%	23%	46%	0
24	2	15%	28%	21%	28%	7%	1
25	2	23%	23%	16%	27%	10%	1
26	3	5%	19%	41%	23%	11%	1
27	3	5%	13%	63%	10%	8%	1
28	All	2%	12%	74%	6%	5%	1
29	2	16%	40%	20%	14%	9%	1
30	3	9%	23%	39%	18%	9%	2
31	4	51%	9%	9%	8%	22%	1
32	1	27%	24%	27%	12%	9%	1
33	2	16%	45%	15%	14%	10%	0
34	3	30%	5%	49%	8%	7%	1
35	2	7%	36%	24%	10%	22%	1
36	5	13%	19%	21%	16%	30%	1
37	4	14%	7%	18%	45%	15%	1
38	1	37%	20%	18%	13%	11%	1
39	2	11%	30%	25%	15%	18%	1
40	3	24%	21%	35%	13%	6%	1
41	2	14%	24%	22%	20%	9%	1
42	3	6%	19%	44%	23%	7%	1
43	2	9%	27%	30%	10%	23%	1
44	1	21%	20%	21%	21%	16%	1
45	1	22%	22%	15%	25%	15%	1
46	1	22%	22%	28%	15%	11%	2
47	2	7%	43%	13%	27%	9%	1
48	5	12%	19%	27%	25%	16%	1
49	4	12%	16%	23%	22%	26%	1
50	4	10%	35%	19%	20%	15%	1

2.2 Paper II and information on answers

2.2.1 Structure of the paper II

Tme : 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. Figure (1) shows the motion of a simple pendulum of length ℓ.

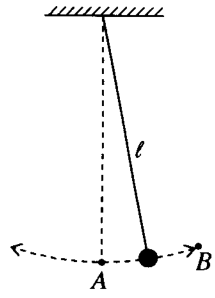


Figure (1)

(*a*) Write down an expression for the period of oscillation T of the simple pendulum in terms of ℓ and acceleration due to gravity, g.

$T = 2\pi\sqrt{\dfrac{l}{g}}$ .... **(01 mark)**

(*b*) In the laboratory experiment to find the value of g, using the simple pendulum you are provided with a stop-watch which can measure the time with an accuracy of 0.5 s. If the estimated value of the period T is 2 s, determine the minimum number of oscillations you should take to reduce the percentage error of T down to 1%.

$$\frac{\Delta T}{T} = \frac{(0.5/n)}{2} = \frac{1}{100}$$

(01 mark)

$$n = 25$$

$$\boxed{T = \frac{t}{n} \rightarrow \frac{\Delta T}{T} = \frac{\Delta t}{t} = \frac{\Delta t}{nT} = \frac{(0.5)}{n \times 2} = \frac{1}{100}}$$

(*c*) A student has designed an electrical method to determine the period of oscillation T more accurately by using a 'detector system'.

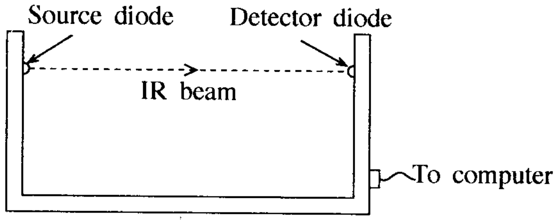


Figure (2)(*a*)

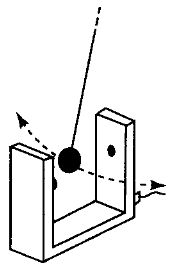


Figure (2)(*b*)

The detector system consists of a source diode and a detector diode. Source diode, emits a narrow beam of Infra-Red (IR) light with a constant intensity of I_0. This light beam is detected by the detector diode, and it also measures the intensity of the beam [see figure (2)(*a*)]. Detector system is placed in the path of the bob of the simple pendulum. While oscillating, the bob also crosses the IR beam [see figure (2)(*b*)]. Whenever the bob interrupts the IR beam, the detector diode signal becomes zero, otherwise it produces a signal of constant intensity I_0. When the bob is oscillating, the computer monitor displays a graph of the variation of the detector signal intensity (I) with time (t).

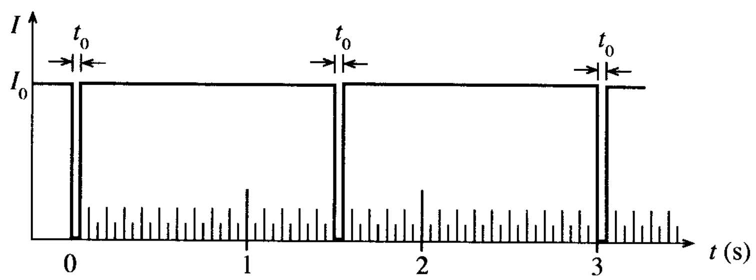


Figure (3)

Figure (3) shows such a graph displayed on the computer screen and is taken in a situation where the force due to **air drag is negligible**. The time interval corresponding to the zero detector signal is t_0 (see figure).

(i) Value of t_0 depends on the speed v with which the bob crosses the IR beam, and the diameter D of the bob. What will happen to the value of t_0 when (1) v is increased (2) D is increased?

(1) Related to v : value of t_0 **decreases**

(2) Related to D : value of t_0 **increases**

For **any** correct answer .... **(01 mark)**

(ii) Write down an expression to estimate v in terms of D and t_0.

$V = \frac{D}{t_0}$ $D = Vt_0$ accepted .... **(01 mark)**

(iii) What is the value of T according to the graph given in figure (3) above?

$T = 3$ s no need of *s* .... **(01 mark)**

(*d*) Student placed the detector system at the most appropriate position of the path of the bob to determine the **maximum speed** v_m of the bob, and obtained a graph similar to the graph shown in figure (3).

(i) With respect to figure (1) above, give the position (A or B) at which the student should keep the detector system in order to determine v_m. Give a reason for your choice.

Answer: : *A*

Reason : Pendulum bob has the **maximum speed/ maximum velocity/ maximum kinetic energy** at point *A*/ at the lowest point of the path

if **both** the answer and the reason correct .... **(01 mark)**

(ii) In order to carry out this experiment, the student says that the cylindrical bob shown in figure (4)(*a*) is better than the spherical bob shown in figure (4)(*b*). If both bobs have same diameter D, give a reason to justify his statement.

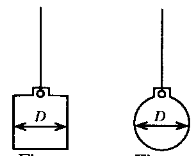


Figure (4)(*a*) Figure (4)(*b*)

IR beam is **not visible** therefore, it is difficult to align the beam through the diameter/*D* **OR**

It is **difficult to align** the beam through the **diameter/*D*** of the spherical bob **OR** It is **easy to align** the beam through the **diameter/*D*** of the cylindrical bob **OR**

The **diameter/*D*** of the **cylindrical bob is uniform throughout. OR**

The **diameter** of the **spherical bob is D only at one location. OR**

Using the **cylindrical bob the error of v can be reduced. OR**

Distance through which the beam is blocked by the cylinder

OR

Any cross section of the bob that blocks the beam by cylindrical bob is *D*

(For any correct reason) .... **(01 mark)**

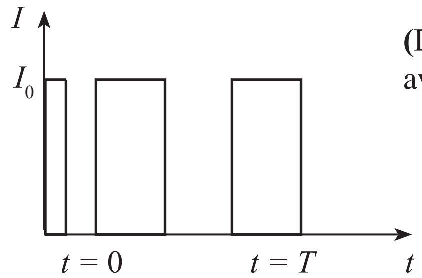
(iii) The student decided to calculate v_m using the graph mentioned above, and the expression in (c)(ii). Can he get the **exact** value for v_m by this method? Explain your answer.

Answer : No .... **(01 mark)**

(Reason : v_m is an instantaneous at the lowest point of the path/ The calulated value is an average value/ approximate value for v_m)

(e) The student observed that in a situation where the force due to air drag is significant, the maximum speed v_m that he obtained, decreases considerably from oscillation to oscillation and the bob finally comes to rest.

(i) For such a situation, complete the graph of (I) with (t) that you would expect for a period of time T on the figure given below.



(Disregards If I_0 is not constant, and award the marks**)**

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

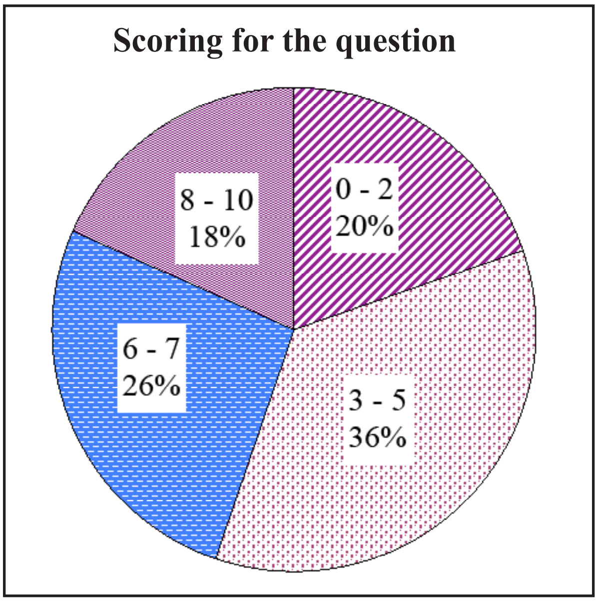
(Width of the zero intensity should increase with time. Labeling on the t axis is not needed. **At least one more** zero intensity region should be clearly drawn, disregard the variation of intensity level)

(ii) If the maximum speeds of the bob at $t = 0$ and $t = T$ are 0.44 m s^{-1} and 0.42 m s^{-1} respectively, estimate the energy loss of the pendulum due to air drag during the time $t = 0$ to $t = T$. Mass of the bob is 100 g.

Energy loss $= \frac{1}{2}\ (0.1)\ (0.44^2 - 0.42^2) = 8.6 \times 10^{-4}$ J .... **(01 mark)**

(For the correct substitution **OR** the final answer)

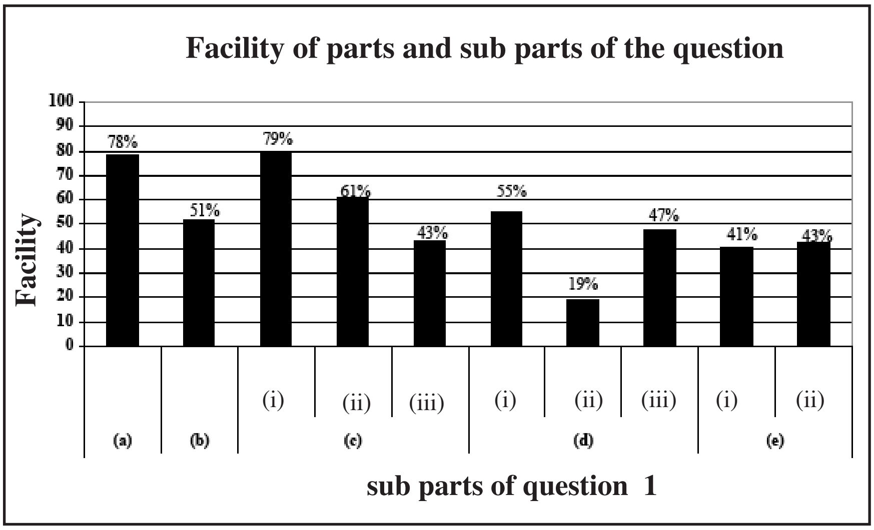
Summary of observations, conclusions and suggestions about answering question 1 :



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

Mark 0-2 class interval 20%,
Mark 3-5 class interval 36%,
Mark 6-7 class interval 26%,
Mark 8-10 class interval 18%.

The percentage of candidates who obtained 8 or more than 8 marks is 18% while 20% of candidates has scored 2 or less than 2 marks.

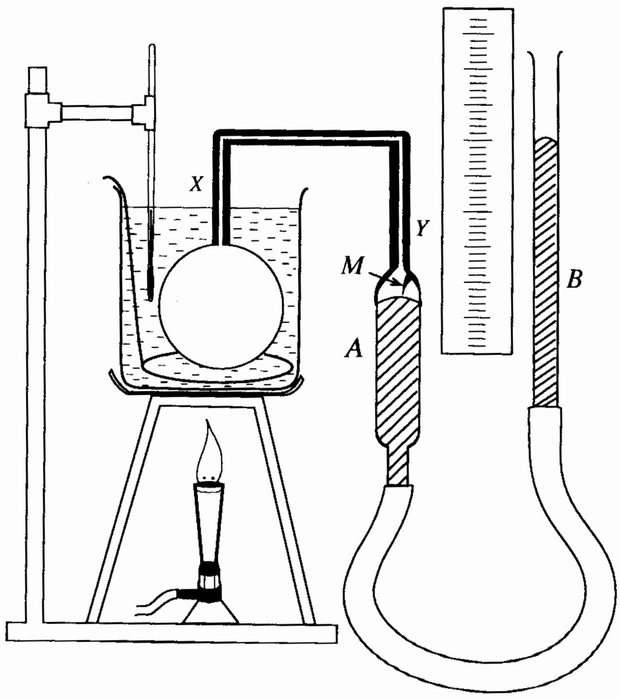


This question has 10 sub-sections and facility indices of 9 sub-sections are higher than 41%. The sub-sections (d) (ii) has the lowest facility index and it is 19%. The sub-section (c) (i) has the highest facility index and it is 79%.

The subpart with the highest facility of 79% is (c) (i) in question number 1. It has tested the fundamental knowledge of how the distance and speed affect on time. subpart (a) has also obtained a facility of 78% and it has expected the relationship among length of the string (l) and gravitational acceleration (g) on period of oscillation (T) directly as the expression.

(d) (ii) has obtained the lowest facility and it is 19%. It seems like most of the students have forgotten that infrared radiation is not visible. (e) (i) has a facility of 41%. There the fact that the speed is reduced with the air resistance has a poor achievement level. Each of the other subparts has a facility in between 41% to 60%.

2.



The experimental setup shown in the above figure is used to verify the pressure law for a gas.

(*a*) The pressure law can be applied to a gas only if two variable quantities pertaining to the gas are kept constant. What are those quantities?

(i) mass / number of moles (ii) volume

(if **both** are correct)) .... **(01 mark)**

(*b*) What is the reason for using the capillary tube *XY* in this setup?

To **minimize/ neglect** the amount of gas **outside the bulb.**
OR to **minimize/neglect** the amount of the gas not in the required/measured temperature.

(01 mark)

(*c*) Explain why it is necessary to increase the temperature of the water bath slowly in this experiment.

To ensure that the **temperature** of the **gas** inside the bulb and the **water** bath are **equal**.
OR to ensure that the **thermometer reading closely follows the temperature of the gas** in the bulb **(01 mark)**

(*d*) Even if the temperature of water is maintained at a certain value it does not mean that the temperature of the gas inside the bulb has reached the same value. In this experiment, how would you make sure that the temperature of the gas inside the bulb has reached the temperature of

Ensuring a **steady / unchanged mercury level** in tube *A*/*B* while maintaining a constant temperature in the water bath/ temperature .... **(01 mark)**

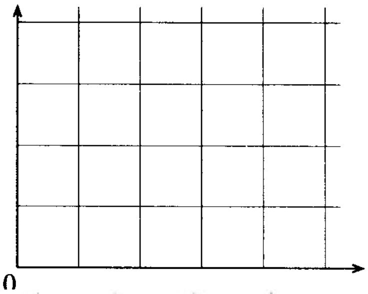
(*e*) Write down the **two** main steps used in the experimental procedure to maintain the temperature of water at a suitable value before measuring that temperature in this experiment.

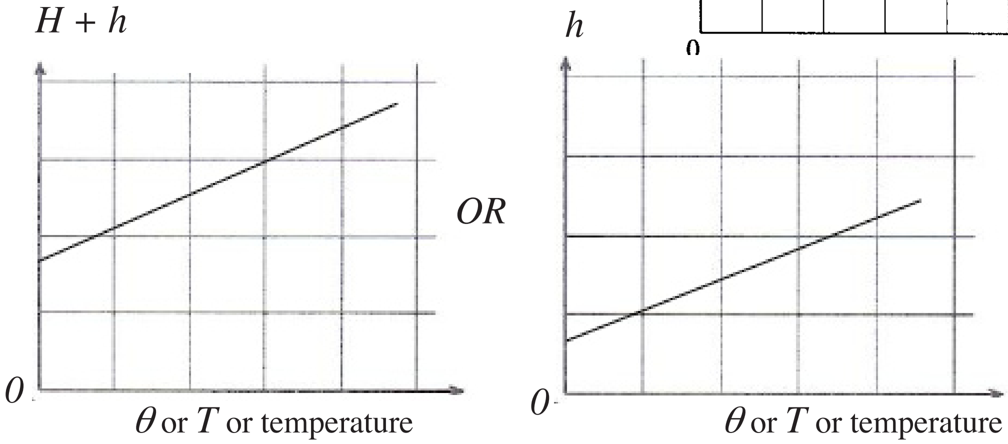
(i) **Stirring** the water in the water bath.
(ii) **Moving the Bunsen burner** (in and) out of the water bath
(iii) adjusting the flame (high and low).

(if both are correct) .... **(01 mark)** (*f*) Write down the main step in the experimental procedure that you would follow before taking the relevant readings to obtain the pressure of the gas.

By **moving the tube** B up and down until the mercury level in tube touches the tip of M / fixed mark / pointer .... **(01 mark)**

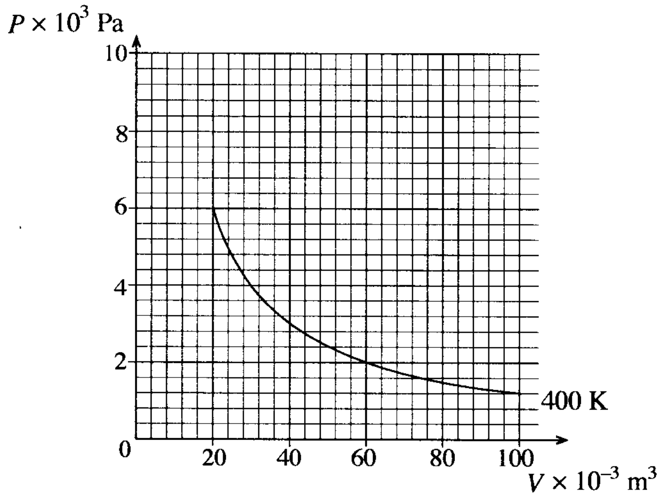
(*g*) If the atmospheric pressure is H centimetres of mercury and the height difference of the two mercury levels of the tubes A and B is h centimetres, draw a rough sketch of the graph that you would plot in the given diagram in order to verify the pressure law. Label the axes correctly.





- For labeling the axes and drawing a straight line as shown ....**(01 mark)**

(*h*) The graph below shows the variation of pressure P with volume V for an ideal gas at temperature 400 K.



(i) Calculate the values P_1 and P_2 of pressures corresponding to the volumes 20×10^{-3} m^3 and 60×10^{-3} m^3 of the gas at temperature 600 K.

Using the pressure law $= \dfrac{P_1}{T_1} = \dfrac{P_2}{T_2} \Rightarrow P_2 = \dfrac{P_1}{T_1} T_2$ *OR*

Using the gas law $= \dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$, since $V_1 = V_2 \Rightarrow P_2 = \dfrac{P_1}{T_1} T_2$

(*OR* a correct substitution as shown below) .... **(01 mark)**

P_1 $\qquad\qquad\qquad$ P_2

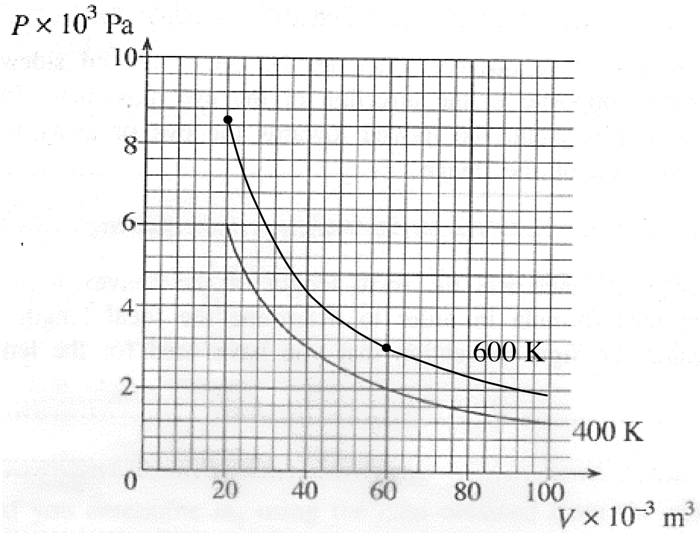
For $V = 20 \times 10^{-3}$ $\qquad$ For $V = 60 \times 10^{-3}\ m^3$,

$P_1 = \frac{6 \times 10^3}{400} \times 600 = 9 \times 10^3 Pa$ $\qquad$ $P_2 = \frac{2 \times 10^3}{400} \times 600 = 3 \times 10^3\ Pa$

Calculation at least one ***P*** value correctly .... **(01 mark)**

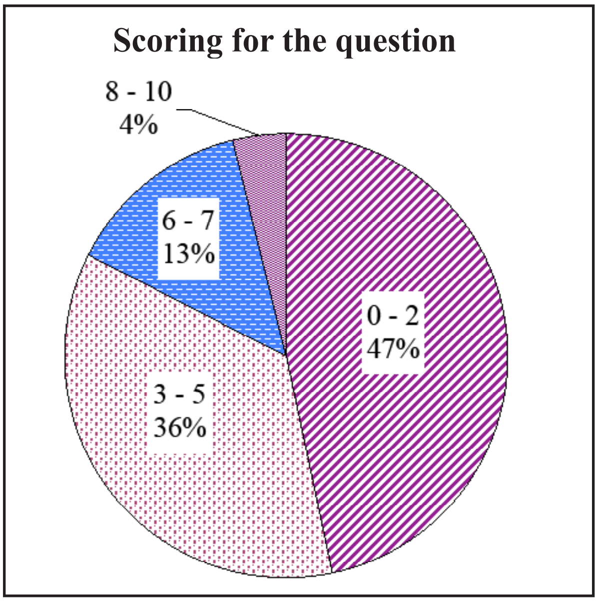
(Award both marks if the student calculated both ***P*** values correctly without mentioning the presure / gas law)

(ii) Mark the points corresponding to the values that you have obtained in (*h*)(i) above, on the graph given under (*h*) above and draw a rough sketch of a curve to show the variation of the pressure with volume at 600 K of the gas on the same graph.



For marking the two correct values of points P_1 and P_2 on the graph and connecting the two points with a curve as shown above. Ignore the curve beyond the two points. **(01 mark)**

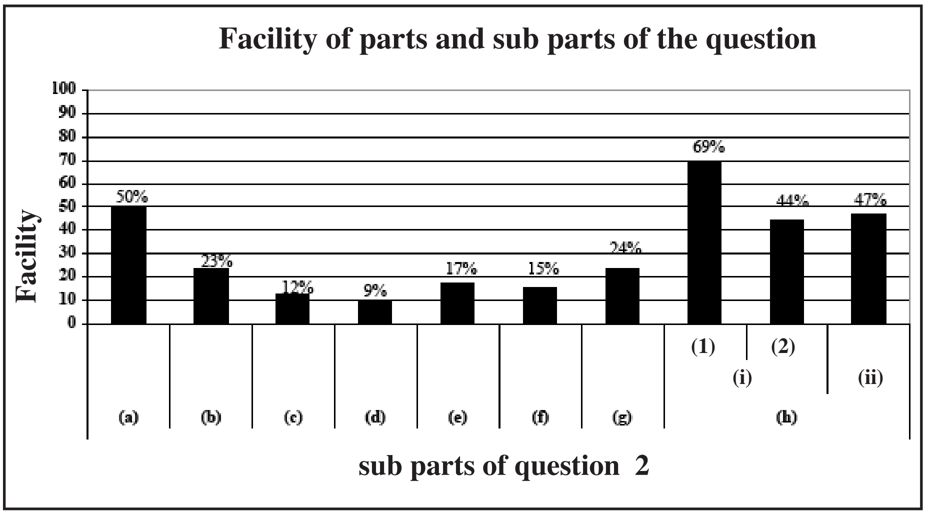
Summary of observations, conclusions and suggestions about answering question 2 :



Although the second structured essay question which carries 10 marks is compulsory only 99% of the candidates have answered. The marks distribution was as follows.

Mark 0-3 class interval 47%
Mark 4-7 class interval 36%
Mark 8-11 class interval 13%
Mark 12-15 class interval 4%

4% of the candidates have obtained 8 or more than 8 marks and 47% have obtained only 2 or less than 2 marks for this question.



There are 10 subparts in this question and the facility is less than 40% in 6 subparts. The subpart wih the lowest facility is (d) and it is 9%. The subpart with the highest facility is (h) (i) (1) and it is 69%.

There is a 69% facility for subpart (h)(i) (1) and it has asked to obtain the answers by substituting the data for the pressure to the equation at two instance.

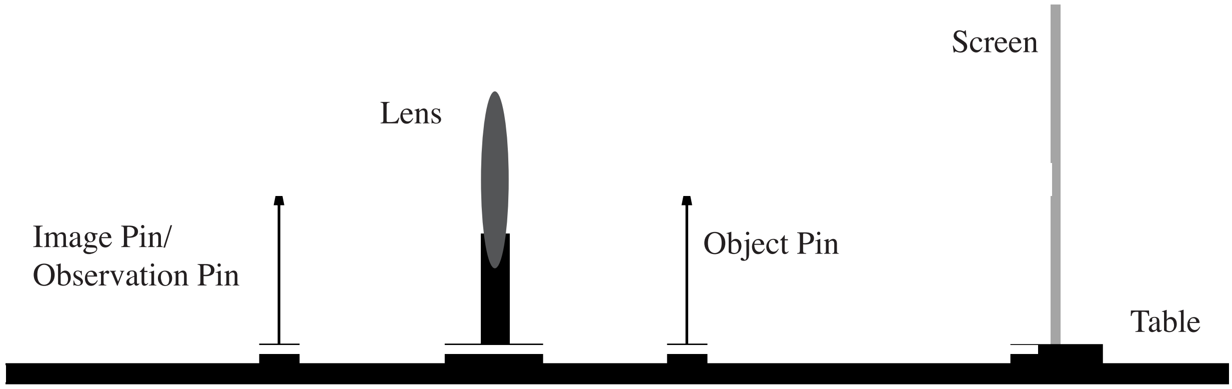
Facility of part (a) has 50% due to improper knowledge on the situations where the law of pressure is applicable. Facility of part (b) has been reduced up to 23% due to low achievement level regarding the methods of reducing the air volume at out side. Low achievment level regarding the conditions required for the practical has reduced the facility of part (c) upto 9%. Facility of part (d) is less than 9%. Beacuse the fact that gas in the bulb and the water in water bath are at thermodynamic equilibrium when the mercury level is constant, has not been realized by the students.

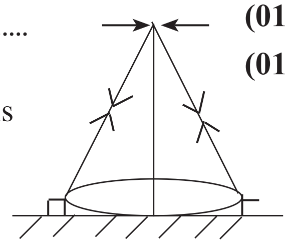
Part (e) and (f) has facilities as low as 17% and 15% respectively due to improper knowledge on maintaining a constant temperature by stiring and controlling the flame. A higher facility would be obtained, if a proper study has been due on practicals.

Facility of (g) is 24% due to low achievement level regarding seperating the variables from a set of given symbols. Facility of (h)(i) (2) is 44% due to low achievement level regarding a graph and calculating the values on a graph. The proficiency can be improved by paying enough attention to the practicals in the laboratory and by engaging in structured questions from the past examination papers.

3. You are asked to determine the focal length of a convex lens experimentally using the no-parallax method. Assume that you are provided with all the items necessary to carry out this experiment.

(*a*) Draw a diagram to show how you would setup all the necessary items on the table to carry out this experiment and label the items. (Stands on which the items are mounted should be clearly drawn.)





Labeling (all four items) .... **(01 mark)**

Items with stands (all four items) .... **(01 mark)**

(All the items should be properly placed in order to award this mark)

(Give marks for any other acceptable diagram)

(*b*) Before setting up the items for the experiment, it is convenient to know a certain data pertaining to a certain item given. What is this data? Describe a simple method to obtain an approximate value for this data.

(Approximate) **focal length** of the lens .... **(01 mark)**

Estimate the focal length by **focusing an image of a distant object** onto a wall, board **(01 mark)**

(*c*) Suppose that when looking at the image after setting up all the items as indicated in (*a*), you have observed that the image and the observation pin are not in the same vertical line. Give **two** reasons, one related to the pins and the other related to the lens, as to why this has happened.

(i) Pins : Pins are not on optical (principal) axis .... **(01 mark)**

(ii) Lens : Lens is tilted .... **(01 mark)**

(*d*) In this experiment, suppose you have observed that, as the eye is moved sideways across the optical axis, the image moves opposite to the direction of the eye movement. In this situation, state whether the observation pin should be moved towards the eye or away from the eye in order to locate the exact position of the image.

Observation pin should be moved towards the eye .... **(01 mark)** (*e*) If the object distance, image distance and the focal length of the convex lens are u, v and f respectively, rearrange the lens formula in order to determine the focal length of the lens by plotting a linear graph. State the sign convention that you have used for the lens formula.

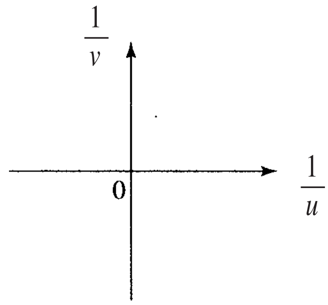
$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$ For Cartesian/ the correct definition

OR

$$\frac{1}{v} = -\frac{1}{u} + \frac{1}{f}$$ For Real - positive and Virtual - negative

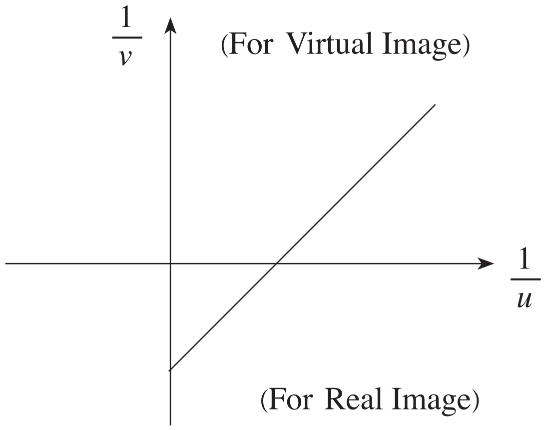
.... **(01 mark)**

(*f*) Mark the independent variable of the equation obtained in (*e*) above on the horizontal axis and the dependent variable on the vertical axis of the given diagram.

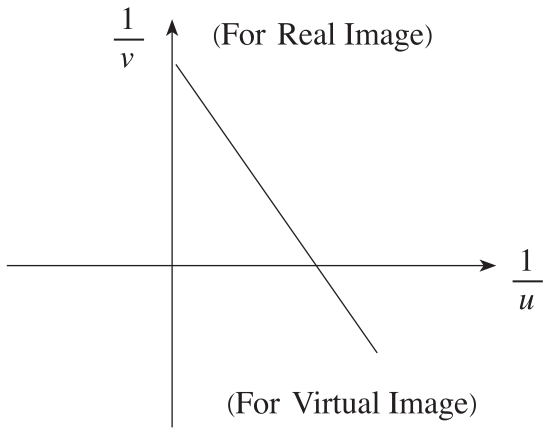


Correct labeling (both axes) .... **(01 mark)**

(*g*) Draw a rough sketch of the expected graph on the same diagram. Use the signs for the object distance and image distance according to the sign convention used in (*e*).



OR



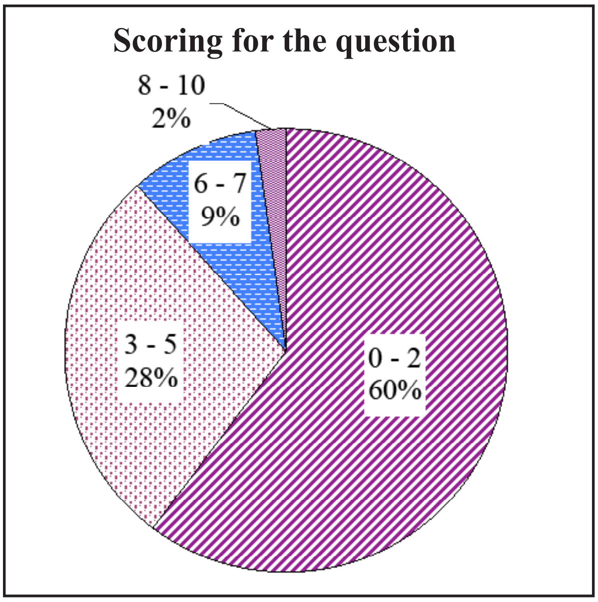
Cartesian sign convention

For Real - positive,
Virtual - negative sign convention

(Correct graph according to the sign convention)... **(01 mark)**

Note: If the pins are marked on the same side of the lens in part (a) (virtual Imag) graph should be drawn accordingly in the correct quadrant.

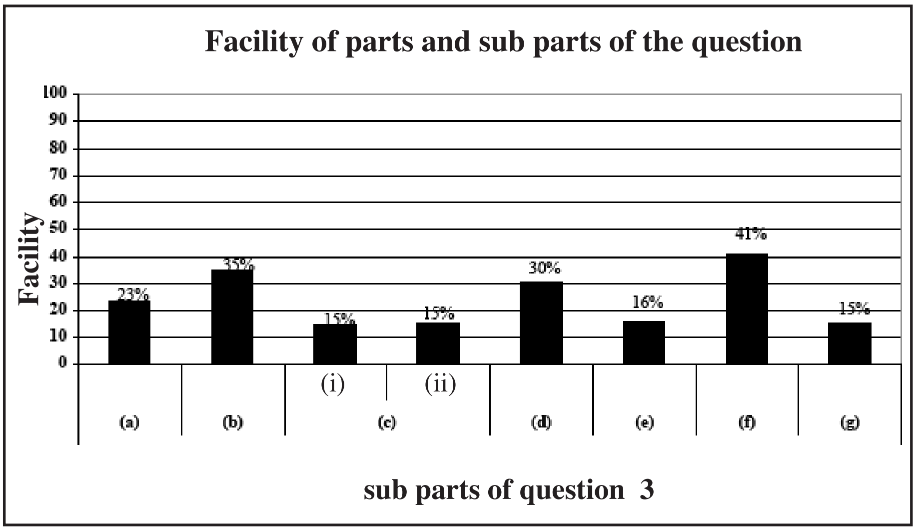
Summary of observations, conclusions and suggestions about answering question 3 :



Although question number 3 is compulsory only 99% have answered. This question carries 10 marks. The marks distribution was as follows.

Mark 0-2 class interval 60%
Mark 3-5 class interval 28%
Mark 5-7 class interval 9%
Mark 8-10 class interval 2%

2% of the candidates have obtained more than 8 marks and 60% of the candidates have obtained less than 2 marks.



There are 8 subpart in this question. The subpart with the highest facility is (f) and it is 41%. The subparts with lower facilities are (c) (i), (c) (ii) and (g) and it is 15%.

Although this is a question regarding convex lenses which can be acqured a higher facility, the percentage of candidates who have obtained 8-10 marks is 2%.

The maximum faciliy of 41% is there for subpart (f). The students should be guided to find a constant or an unknown term by rearranging the equation and by a graphicl methods. The students with the above ability had reached a maximum level of achievement. Facility of subparts (c)(i) and (c)(ii) are 15% each. It is certain that the achievement level would be increased if the students have enough practice regarding obtaining the reasings with a minimum error and thinking of precautions in keeping the lense are on principal axis and correct handling. The facility of subpart (e) is 16%. It is necessary to train the students for laboratory practicals and to teach them the theoretical equation for both real and virtual situations.

4. (*a*) An incomplete diagram of a potentiometer circuit that is being used in the laboratory to determine the internal resistance r_0 of a standard cell of e.m.f. E_0 (< E) is shown in figure (1).

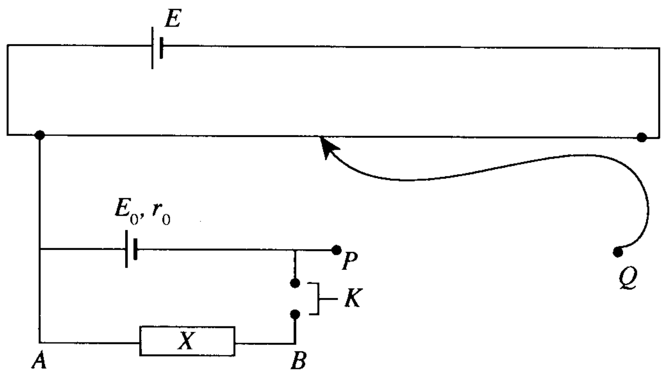
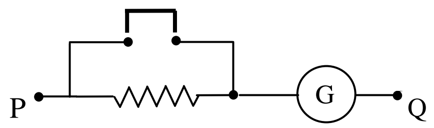
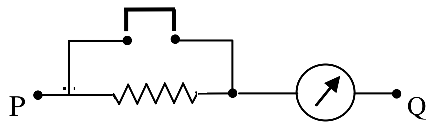


Figure (1)

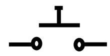
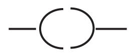
(i) Complete the section of the circuit between P and Q using **standard circuit symbols**.



OR



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

[Other possible switch symbols:  *OR*  *OR* ]

(All three items must be drawn to earn the mark)

(ii) What is the item used in the laboratory for X to obtain a resistance R?

Resistance box .... **(01 mark)**

(No marks for other items)

(iii) If ℓ is the balance length of the potentiometer wire, and k is the potential drop per unit length of the potentiometer wire, derive an expression for the product $k\ell$ in terms of E_0, r_0 and R.

$V_{AB} = \frac{E_0 R}{r_0 + R}$ .... **(01 mark)**

$kl = \frac{E_0 R}{r_0 + R}$ .... **(01 mark)**

(Award marks for any correct derivation)

(*b*) A student decided to modify the above setup to determine the resistance per unit length (m_0) of a nichrome wire by replacing the item X of the circuit with the nichrome wire of length ℓ_1.

(i) If the balance length of the potentiometer wire in this case is ℓ_2, modify the expression that you have given under (*a*)(iii), and write down an expression for product $k\ell_2$ in terms of E_0, m_0, ℓ_1 and r_0.

$kl_2 = \frac{E_0 m_0 l_1}{r_0 + m_0 l_1}$ .... **(01 mark)**

(For any correct manner)

(ii) Rearrange the expression that you have given under (b)(i) in a suitable manner to plot a graph between $\frac{1}{\ell_2}$ and $\frac{1}{\ell_1}$, taking $\frac{1}{\ell_1}$ as the independent variable.

$$\frac{1}{kl_2} = \frac{r_o + m_o l_1}{E_o m_o l_1}$$

$$\frac{1}{l_2} = \frac{kr_o}{E_o m_o}\cdot\frac{1}{l_1} + \frac{k}{E_o}$$ .... **(01 mark)**

(iii) How would you determine m_0 using the data obtained from the graph mentioned in (b)(ii) above and the value of r_0?

$$\frac{m_0}{r_0} = \frac{\text{Intercept}}{\text{Gradient}} \quad OR \quad m_0 = r_0\,\frac{\text{Intercept}}{\text{Gradient}}$$ .... **(01 mark)**

(iv) If the nichrome wire provided to the student has a diameter of 1.6×10^{-4} m, calculate the length of the wire necessary to obtain a resistance of 50 Ω. Resistivity of nichrome is 10^{-6} Ω m. (Take π as 3)

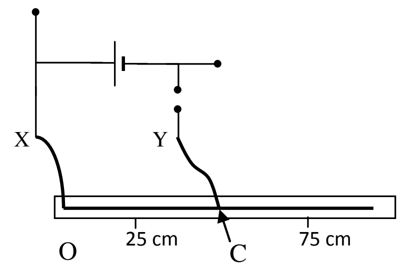
$$R = \frac{\rho l}{A} \quad OR \quad l = \frac{RA}{\rho} \quad OR \quad l = \frac{50 \times [\,3 \times (0.8 \times 10^{-4})^2]}{10^{-6}}$$

$l = 0.96$ m OR 96 cm .... **(01 mark)**

(If π is taken as 3.14 the answer is 1.0 m) with correct substitution

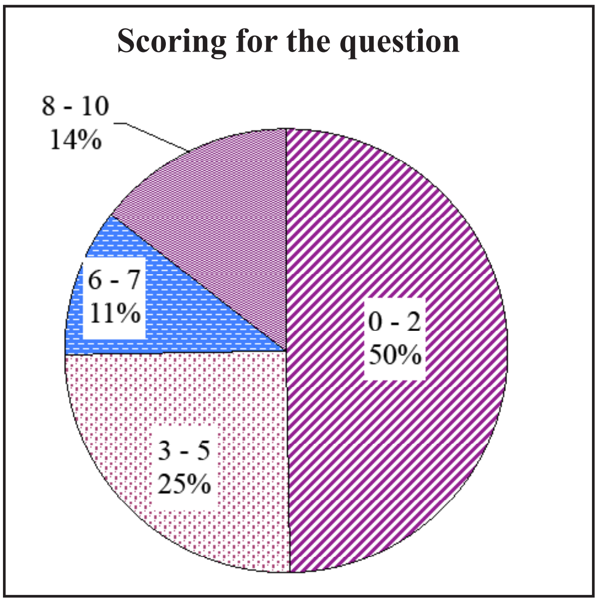
(01 mark)

(v) The nichrome wire of resistance 50 Ω is fixed onto a metre ruler. You are asked to obtain a set of measurements from the potentiometer to determine m_0 using the graph mentioned in (b)(ii) above. By completing the circuit in figure (2) given below, show as to how you would connect the nichrome wire to the potentiometer in order to obtain the relevant measurement for a wire length approximately corresponding to 25 Ω.



(Points O and C of the nichrome wire should be connected to points X and Y of the potentiometer circuit. (Accept any point approximately within 25 cm and 75 cm marks of the metre ruler as a correct point for C). **(01 mark)**

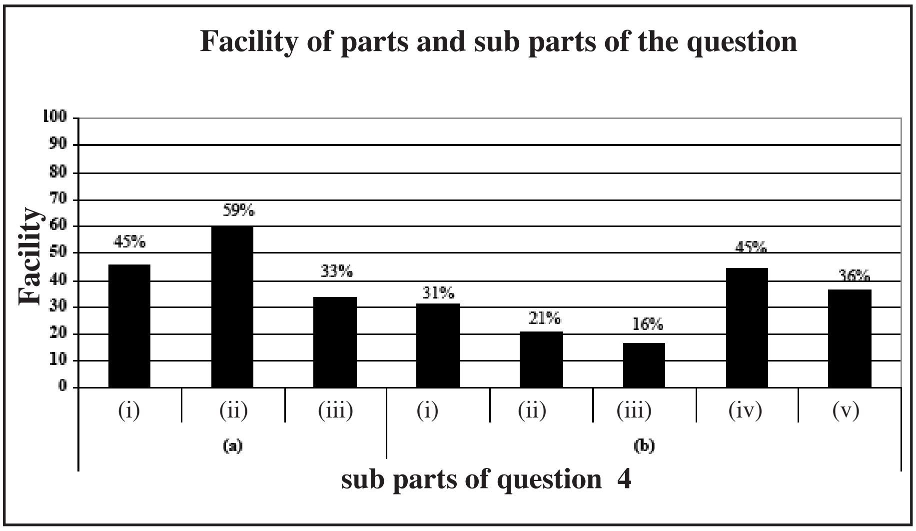
Summary of observations, conclusions and suggestions about answering question 4 :



Although the question number 4 is compulsory only 99% of the candidates have answered. This question carries 10 marks. The marks distribution was as follows.

Mark 0-2 class interval 50%
Mark 3-5 class interval 25%
Mark 6-7 class interval 11%
Mark 8-10 class interval 14%

14% of the candidates have obtained 8 or more than 8 marks 50% have obtained 2 or less than 2 marks.



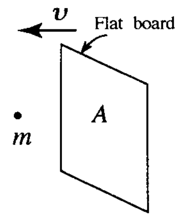
5 subparts out of 8 have a facility of less than 40%. The subpart with the minimum facility is (b) (iii) and it is 16%. The subpart with maximum facility is (a) (ii) and it is 59%.

This is a question related to the principle of potentiometer subpart (a) (ii) has a maximum facility of 59% and subparts (a) (i), (b) (iv) have a facility of 45% each. It shows that the students have a sound practical knowledge regarding variation of resistance and electrical device, and have a good achievement level in reasoning and fundamental principles. But students should develop the ability of understanding the variables and rearranging the variables inorder to plot a graph, and obtaining the values. Separating the variables and explaning the nature of graph logically. There are 3 achievement levels for subparts (b) (i), (b) (ii) and (b) (iiii) as 31%, 21% and 16% respectively.

Students should be directed to obtain the understand the practicals and theory regarding current electricity and by answering past examination questions a higher achievement level can be reached.

Part B - Essay

5. (*a*) A vertical flat board of cross-sectional area A moves in still air at a constant speed v as shown in the figure. Consider the relative motion of the board and the air molecules. Under this condition, assume that the air molecules collide with the surface of the board perpendicularly and after colliding, bounce back in the opposite direction with the same speed v with respect to the board.



(i) If m is the mass of an air molecule, write down an expression for the change in momentum of the molecule.

(ii) Considering the number of air molecules colliding with the board per unit time or otherwise, show that the magnitude of the force F exerted on the board by the air can be given by $F = 2Adv^2$, where d is the density of air. **This force is known as the drag force**.

(*b*) The drag force (F_D) on an object moving in a fluid depends on the shape of the object. A more accurate expression for F_D can be given as $F_D = KAdv^2$, where K is a constant which depends on the shape of the object. Drag force plays an important role in the design of the external shape of vehicles.

Consider a motor vehicle moving in still air on a flat road with a constant speed v. Take $K = 0.20$, $A = 2.0 \text{ m}^2$ for the motor vehicle and $d = 1.3 \text{ kg m}^{-3}$.

(i) Write down an expression for the power (P) needed to overcome the drag force F_D.

(ii) Calculate the power P when the motor vehicle is moving with a speed of 90 km h^{-1} (= 25 m s^{-1}).

(iii) If the power needed to overcome other external frictional forces acting on the motor vehicle is **constant** and is 6 kW, what should be the total power supplied by the drive wheels of the motor vehicle in order to maintain a constant speed of 90 km h^{-1}?

(iv) If the speed of the motor vehicle has been increased from 90 km h^{-1} to 126 km h^{-1} (= 35 m s^{-1}), calculate the **additional power** required to maintain the speed of the motor vehicle at that value.

(v) If the motor vehicle climbs at a constant speed of 90 km h^{-1} on a road of slope of 3°, calculate the **additional power** that should be supplied by the drive wheels. Consider that the mass of the motor vehicle is 1 200 kg. (Take sin 3° = 0.05)

(*c*) Consider a motor vehicle moving on a flat road as described in (*b*)(iii) above. Consider that the energy released by burning one litre of petrol is 4×10^7 J and only 15% of this energy is used to drive the wheels. Under following conditions, calculate the fuel efficiency of this motor vehicle in kilometres per litre.

(i) When it moves in still air.

(ii) When it moves in opposite direction to a wind blowing at constant speed of 36 km h^{-1} (= 10 m s^{-1}).

(a) (i) Initial momentum of an air molecule $= mv$

Final momentum after collision with the board $= -mv$

Change in momentum permolecule $= mv - (-mv)$

$= 2mv$ .... **(01 mark)**

(ii) Total mass of molecules colliding with the board per unit time $= Avd$ ....**(01 mark)**

Rate of change of momentum of air mass $= 2(Avd)v$ **(01 mark)**

(Force = Rate of change of momentum)

$\therefore \; F = 2Adv^2$

(b) (i) $P = F_D v$ .... **(01 mark)**

(ii) $P = KAdv^3$

$= (0.2) \times (2) \times (1.3) \times (25)^3$ .... **(01 mark)**

$= 8125$ W (8120 W 8125 W) .... **(01 mark)**

(iii) Total Power $= 8125\text{ W} + 6000\text{ W}$

$= 14125\text{ W}$ (14120 W – 14125 W) .... **(01 mark)**

(iv) Power required to maintain the speed at 126 kmh^{-1} (35 m s^{-1})

$= KAdv^3 = (0.2) \times (2) \times (1.3) \times (35)^3$

$= 22295W$ (22290 W – 22295 W) .... **(01 mark)**

Additional power required $= 22295W - 8125\text{ W}$

$= 14170\text{ W}$ (14165 W – 14175 W) .... **(01 mark)**

Alternative Method : 1

Additional power required to maintain speed at 126 kmh^{-1} (35 m s^{-1}),

$= (0.2) \times (2) \times (1.3) \times [(35)^3 - (25)^3]$ .... **(01 mark)**

$= 14170\text{ W}$ (14165 W – 14175 W) .... **(01 mark)**

Alternative Method : 2

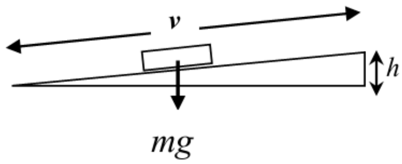
Power is proportional to v^3 and other power requirements remain constan.

Additional power required to maintain speed at 126 kmh^{-1} (35 m s^{-1}),

$= \left[8125\left(\frac{35^3}{25}\right) - 8125\right]$ .... **(01 mark)**

$= 14170\text{ W}$ (14165 W – 14175 W) .... **(01 mark)**

(v) Vehicle travels a distance v in unit time along the slope and during this time interval it has been lifted to a vertical height $h = v\sin 3^0$.



Required additional power $= mgv\sin 3^0$ .... **(01 mark)**

$= 1200 \times 10 \times 25 \times 0.05$

$= 15000\text{ W}$ .... **(01 mark)**

Alternative Method :

Backward force due to its weight $= 15\sin 3^0$

Required additional power $= mgv\sin 3^0\ v$ .... **(01 mark)**

$= 1200 \times 10 \times 25 \times 0.05$

$= 15000\text{ W}$ .... **(01 mark)**

(c) Amount of energy used for driving the wheels by burning 1 liter of petrol $\Big\} = (4 \times 10^7) \times \frac{15}{100} = 6 \times 10^6 \text{ J } l^{-1}$

(i) Energy required per second to maintain a speed of 90 kmh^{-1} $\Big\} = 14125 \text{ J s}^{-1}$ $(14120 - 14125) \text{ J s}^{-1}$ [from b(iii)]

Total time that the vehicle can be driven by during 1 liter of petrol $\Big\} = \frac{6 \times 10^6}{14125}$ **(01 mark)**

(For correct substitution)

$= 424.8 \text{ s } l^{-1}$

Distance travelled in 424.8 s $= (25 \times 10^{-3}) \times (424.8)$

Fuel efficiency $= 10.6 \text{ Km } l^{-1}$ .... **(01 mark)**

Alternative Method:

Energy required per second to maintain a speed of 90 km h^{-1} ,

$= 14125 \text{ J s}^{-1}$ $(14120 - 14125) \text{ J s}^{-1}$ [from b(iii)]

Time taken to 1 km (in second) $= \frac{90}{60 \times 60}$ Km speed $= \frac{90}{60 \times 60}$ Kms^{-1}

Distance traveled using 1 liter of petrol $= \frac{6 \times 10^6}{14125} \times \frac{90}{60 \times 60}$ ...... **(01 mark)**

(correct substitution)

Fuel efficiency $= 10.6 \text{ Km } l^{-1}$ .... **(01 mark)**

(ii) Speed of the vehicle respect to wind $= 90 \text{ km h}^{-1} + 36 \text{ km h}^{-1} = 126 \text{ km h}^{-1}$

Total power required to maintain a speed of 126 km h^{-1} $\Big\} = 0.2 \times 2 \times 1.3 \times (3.5 \times 10)^2 \times 25 + 6000$

$= (21920 - 21925)$

$= 15925 + 6000$

$= 21925 \text{ W}$ $(21920 - 21925)$ .... **(01 mark)**

Fuel efficiency $= \frac{10.6}{21925} \times 14125$

$= 6.8 \text{ Km h}^{-1}$ .... **(01 mark)**

Alternative Method:

Total power required to maintain a speed of 126 kmh^{-1} (35 m s^{-1}),

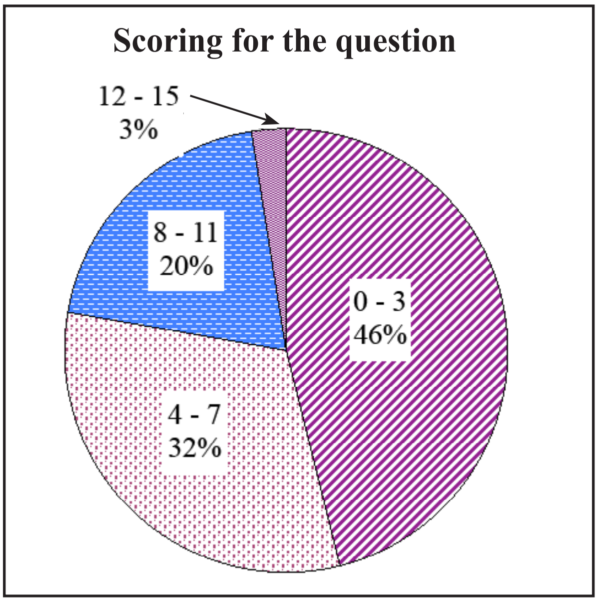
$= [(0.2) \times (2) \times (1.3) \times (35)^2 \times 25] + 6000$

$= 21925 \text{ W}$ .... **(01 mark)**

Fuel efficiency $= \frac{10.6}{21925} \times 14125$

$= 6.8 \text{ Km h}^{-1}$ .... **(01 mark)**

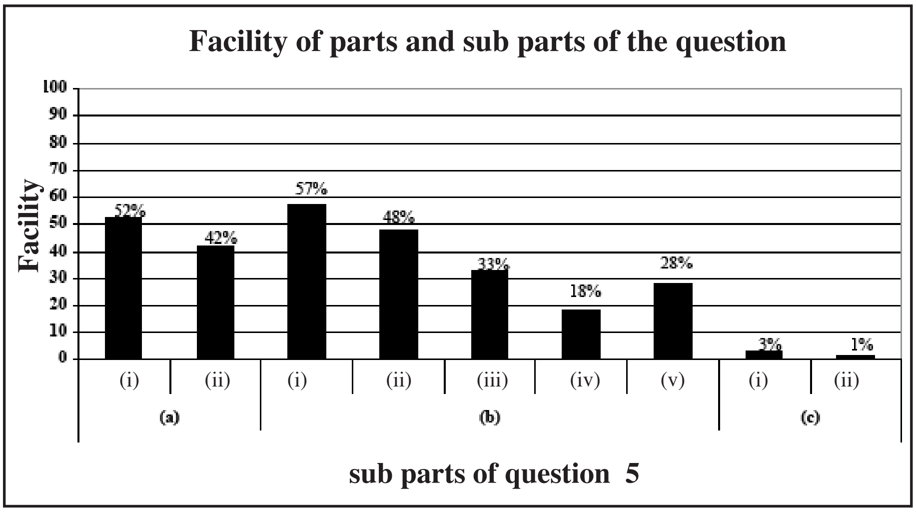
Summary of observations, conclusions and suggestions about answering question 5 :



66% of the candidates have attempted to answer this question. It carries 15 marks.
The distribution of marks obtained is as follows

Mark 0-3 class interval 46%
Mark 4-7 class interval 32%
Mark 8-11 class interval 20%
Mark 12-15 class interval 3%

3% of the candidates have obtained 12 or more than 12 marks for this question and 46% have obtained 3 marks or less than 3 marks.



There are 9 sub parts in this question. Out of those 5 sub parts have exceeded the facility of 40%. Sub part (b) (i) has the highest facility and it is 57%. Sub parts (c) (i) and(c) (ii) have a minimum facility of 5%.

This question has prepared based on the linear momentum, rate of change of momentum, energy and power. 66% of the candidates have selected this question. But only 52% out of the candidates who had selected the question have been able to obtain the expression for the change in momentum in subpart (a) (i). It seems like the candidates have excited regarding the term relative motion. The candidates show a moderate level achievement for the sub parts (b) (ii) and (b) (iii) which ask for the extra power.

Most of the students have shown the difficulties in finding fuel efficiency in sub parts (c) (i) and(c) (ii). Students should be given with a sound understanding, regarding the fuel efficiency. The achievement level of the students should be higher enough to obtain the final answer for two or three decimal places.

6. Read the following passage and answer the questions.

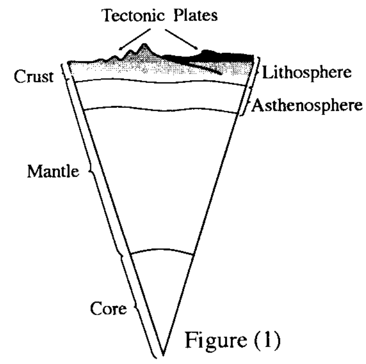


Figure (1)

Earthquakes are one of the powerful natural phenomena on Earth. The internal structure of the Earth is one of the important parameters needed to understand the major seismic activities around the globe. The Earth may be considered to have three major concentric parts, namely the crust, the mantle and the core [see figure (1)]. The lithosphere and asthenosphere are the two outer layers of the Earth. The lithosphere consists of 10 major rigid lithospheric plates called tectonic plates which are considered to be floating on the asthenosphere.

Heat is transferred towards asthenosphere due to the high temperature in the core. The convection currents thus produced in the asthenosphere cause the movements of tectonic plates. When two tectonic plates move with respect to each other, friction sometimes causes two plates to get stuck. When this happens elastic strain energy builds up, until eventually the plates give way creating an earthquake. This stored energy is released creating energetic waves called seismic waves. These seismic waves travel in all directions from the point where the energy is released, and this point is known as the focus of the earthquake. The corresponding point on the Earth's surface, directly above the focus, is called epicentre of the earthquake.

The Earth's crust supports propagation of travelling waves. The waves which travel through the crust are called body waves and those travel on the surface are called surface waves. The body waves consist of P (primary) waves and S (secondary) waves. P waves are longitudinal whereas the S waves are transverse. Since any material, solid or fluid, can be subjected to compression, the P waves can travel through any kind of material. However, S waves which depend upon shear force, do not exist in a fluid. The absence of S waves at large distances from an earthquake was the first indication that the Earth has a liquid region also. The P waves from an earthquake arrive at a given location before the S waves and surface waves.

There is a large number of seismic data recording stations throughout the world. In order to find the distance d from such a station to the epicentre, one needs to measure the difference in arrival times Δt of P and S waves to the station [see figure (2)]. The distance d is given by $d = \left[\dfrac{v_P v_S}{v_P - v_S}\right]\Delta t$, where v_P and v_S are speeds of P and S waves respectively. The location of the epicentre can be found using the d values from at least three recording stations. By drawing three circles with radii corresponding to the distances (d values) measured, and using the common point of intersection of the circles (triangulation), one can find the location of the epicentre.

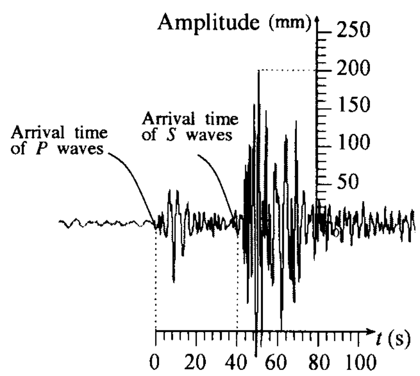


Figure (2)

Richter scale is the most accepted method used to estimate the strength of an earthquake. Distance d of the epicentre from the station and the **maximum** amplitude A_m of the seismic waves recorded at the station can be used to estimate the Richter scale magnitude M of an earthquake using the nomogram shown in figure (3). The magnitude M of an earthquake is related to the released energy E (in joules) by the equation, $\log_{10} E = 4.4 + 1.5M$.

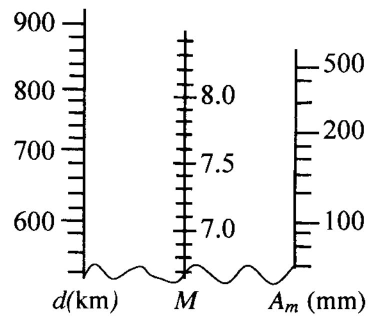


Figure (3)

(*a*) What are the **three** major parts of the interior of the Earth?

(*b*) Explain, why the tectonic plates are in continuous motion?

(*c*) What is the relationship between focus and epicentre of an earthquake?

(*d*) Even though P waves can travel through any part of the Earth, S waves can only travel in the solid parts of the Earth. Explain why?

(*e*) Draw **two** separate diagrams for the propagation of P and S waves indicating the direction of propagation and the direction of vibration of particles in the medium by arrows. Label them clearly.

(*f*) What was the first experimental observation which indicates the existence of a liquid region in the internal structure of the Earth?

(*g*) Using an appropriate diagram, illustrate the triangulation method used in seismology. Clearly mark the location of the epicentre as point O and S_1, S_2 and S_3 as the locations of the corresponding stations in your diagram.

(*h*) If the graph in figure (2) is a seismogram obtained by a certain station with regard to the recent earthquake in Nepal, find the value of Δt in seconds, and calculate the value of d in kilometres for this station. Take $v_P = 5 \text{ km s}^{-1}$ and $v_S = 4 \text{ km s}^{-1}$.

(*i*) Using the nomogram in figure (3) above, estimate the Richter scale magnitude M of the earthquake mentioned in (*h*) above.

Hint: Mark the values of d and A_m on the correct axes. Draw the line connecting the two points (d and A_m) and read the value of the point of intersection of the line with the M axis. You **do not need** to copy the nomogram to your answer script.

(*j*) Calculate the total energy E_N released from the earthquake in Nepal in joules.

(*k*) If E_S is the total energy released and $M = 9.1$ for 2004 Sumatra earthquake, calculate the ratio, $\frac{E_S}{E_N}$. Take $10^{1.8} = 63$.

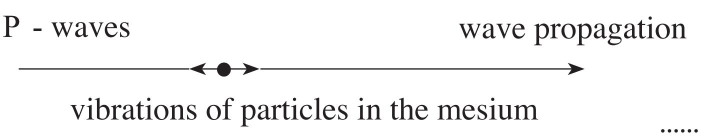
(a) the crust, the mantle and the core (all three correct) .... **(01 mark)**

(b) due to the convection currents within the asthenosphere.............................. **(01 mark)**

(c) the point on the Earth's surface, directly above the focus, is earthquake's epicenter. **(01 mark)**

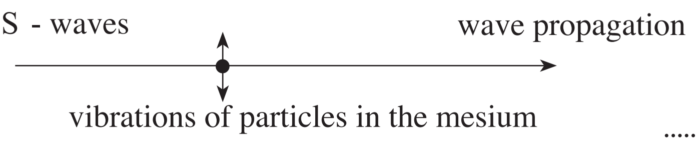
(d) P waves are compressional waves which can travel through any part of the Earth (solid or liquid). However, S waves depend upon shear force which does not exist in a fluid. **(01 mark)**

(e) P - waves



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

S - waves

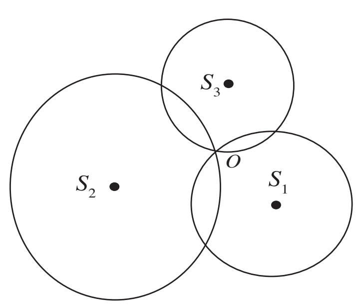


....**(01 mark)**

(Vibrations of particles should be indicated by two arrows and at least one diagram should be labeled properly)

(f) The absence of S waves on seismogram at large distances from earthquakes. ....**(01 mark)**

(g)



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

[01 mark for the three circles with a common intersection
01 mark for the correct point *O*.]

(Stations can be located on any side of the point O. Full circles not needed)

(h) $\Delta t = 40$ s .... **(01 mark)**

$$d = \left[\frac{5 \text{ km s}^{-1} \times 4 \text{ km s}^{-1}}{5 \text{ km s}^{-1} - 4 \text{ km s}^{-1}}\right] 40 \text{ s}$$

$= 800$ km (OR 8×10^5) .... **(01 mark)**

(i) $M = 7.9$ .... **(01 mark)**

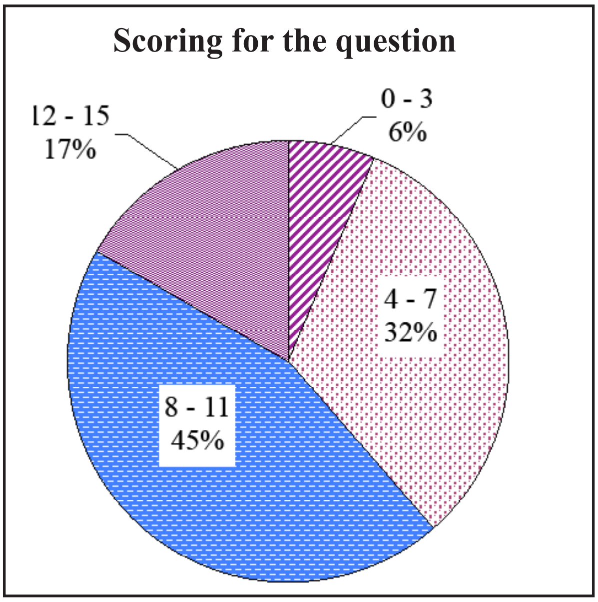
(j) $\log E = 4.4 + 1.5\,(7.9)$ (for substitution of M)

$E = 1.8 \times 10^{16} J$ $(1.78 - 1.80) \times 10^{16} J$ .... **(01 mark)**

(k) $\log \left(\frac{E_S}{E_N}\right) = 1.5\,(9.1 - 7.9)$ .... **(01 mark)**

$\left(\frac{E_S}{E_N}\right) = 10^{1.8} = 63$ .... **(01 mark)**

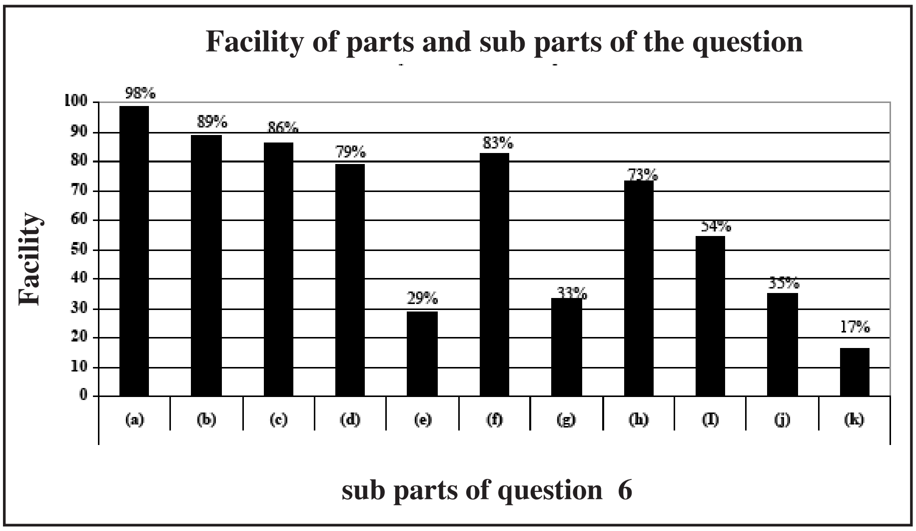
Summary of observations, conclusions and suggestions about answering question 6 :



88% of the candidates have selected the question number six. This question carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 6%
Mark 4-7 class interval 32%
Mark 8-11 class interval 45%
Mark 12-15 class interval 17%

17% of the candidates have obtained more than 12 marks for this question.



There are 11 sub parts in this question. Out of those, 7 sub parts have exceeded the facility of 50%. Sub part (k) has the lowest facility and it is 17%. Sub part (a) has the highest facility of 98%.

This question has been selected by a highest percentage of candidates like 88%, is prepared based on the seismic waves from the unit oscillations and waves. The sub parts (a), (b), (c) and (f) shows a higher facility of more than 83%. Sub part (d)has a facility of 79%. It can state the fact, that it is necessary to know the importance of reading and understanding the content of the paragraph.

The least achievement level was there for the sub part (k) and it was 17%. The achievement level could be increased by helping them to thorough the knowledge regarding indices and logarithms.

The achievement level is 33% for the sub part (g). Inability to understand the facts in the paragraph is the reason for this. Therefore it is essential to train the students to read the paragraphs and extract the information even in the term tests.

7. (*a*) In the human body, if the length of a bone is larger than its width then it is classified as a 'long bone'. The tensile stress $\left(\frac{F}{A}\right)$ – strain $\left(\frac{\Delta \ell}{\ell}\right)$ curve for a certain 'long bone' is shown in figure (1). Here, all the symbols have their usual meaning.

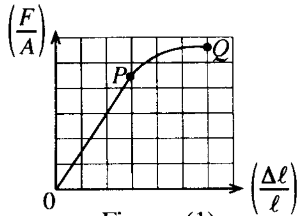


Figure (1)

(i) Identify the points P and Q marked on the curve shown in figure (1).

(ii) Assume that the 'long bone' is a uniform rod of area of cross-section 3×10^{-4} m^2 . If a tensile force of magnitude 4.5×10^3 N is applied, calculate the tensile stress on the bone.

(iii) If the Young's modulus of the 'long bone' is 1.5×10^{10} N m^{-2}, calculate the tensile strain of the bone.

(iv) If the initial length of the 'long bone' is 25 cm, what is the length when the tensile force is applied?

(*b*) Table given below shows the elastic characteristics of one of the long bones of the human body; the femur (the long bone in the thigh), obtained under tension and compression.

Elastic characteristics	**Tensile value**	**Compressive value**
Young's Modulus	1.60×10^{10} N m^{-2}	1.00×10^{10} N m^{-2}
Stress corresponding to the fracture point	1.20×10^{8} N m^{-2}	1.65×10^{8} N m^{-2}
Strain corresponding to the fracture point	1.50×10^{-2}	1.75×10^{-2}

(i) Using the values given in the table above for a femur, show that for the same value of stress, the compressive strain is 1.6 times the tensile strain.

(ii) Under which condition (tension or compression) the femur is more susceptible to fracture? Use the values given in the table above to justify your answer.

(*c*) When a person stands on a single leg the total weight of the person creates a compressive effect on the leg. Consider a situation that one of the femurs supports the entire body mass of 75 kg of a person who is walking. Consider that the femur is a thick-walled cylinder of uniform cross-section with an inner cavity. Its outer and inner radii are 1.5 cm and 0.5 cm respectively. For the following calculations, use the values given in the table above.

(i) When the person stands on a single leg, find the compressive stress applied to his femur. (Take π as 3)

(ii) Find the strain corresponding to the situation in (*c*)(i) above.

(iii) For a human to stand on a single leg without feeling uncomfortable under ordinary standing conditions, the strain on the femur must be less than 1% of the value of the strain indicated in the table above. Hence show that when the above mentioned person stands on one leg he does **not** feel uncomfortable.

(iv) Consider a person having all body dimensions doubled including all bones compared to an ordinary person. Let the mass of such a person be 600 kg. If the scaled-up person now stands on one leg, does he feel uncomfortable? Justify your answer. Assume that the elastic characteristics given in the table above remain unchanged for the situation.

(a) (i) P - **Proportionality limit** .... **(01 mark)**

(No marks for the Proportionality point/ elastic limit)

Q - Breaking point OR Fracture point.. **(01 mark)**

(ii) Tensile Stress $= \dfrac{F}{A} = \dfrac{4.5 \times 10^{3}}{3 \times 10^{-4}}$

$= 1.5 \times 10^{7}$ Nm^{-2} .... **(01 mark)**

(iii) Tensile Strain $= \left(\frac{\Delta l}{l}\right) = \left(\frac{\frac{F}{A}}{E}\right) = \frac{1.5 \times 10^{7}}{1.5 \times 10^{10}}$

$= 10^{-3} = 0.001$ .... **(01 mark)**

(iv) New length $= l^{2} = (l + \Delta l) = \left(l + \frac{\Delta l}{l}\right) = l\,(1 + 0.001)$

$=$ 0.25025 m **OR** 25.025 cm .... **(01 mark)**

(if the answer given in cm units must be stated)

(b) (i) $\frac{\left(\frac{\Delta l}{l}\right)_{\text{Compressive}}}{\left(\frac{\Delta l}{l}\right)_{\text{Tensile}}} = \frac{E_{\text{Tensile}}}{E_{\text{Compressive}}} = \frac{1.6 \times 10^{10}}{1.6 \times 10^{10}}$ .... **(01 mark)**

$= 1.6$ (For the correct expression)

(ii) Answer: Under tension

Justification: Stress corresponding to the fracture point,
Under compression $(1.65 \times 10^{8}\,\text{Nm}^{-2})$ > under tension $(1.20 \times 10^{8}\,\text{Nm}^{-2})$

OR

Justification: Strain corresponding to the fracture point,
under compression (1.75×10^{-2}) > under tension (1.50×10^{-2})
(If the answer **and** one of the correct justifications given) .... **(01 mark)**

(c) (i) Compressive stress $= \frac{75 \times 10}{\pi(1.5^{2} - 0.5^{2}) \times 10^{-4}}$ .... **(01 mark)**

$= 1.25 \times 10^{6}\,\text{Nm}^{-2}$ .... **(01 mark)**

(if π taken as 3.14 the answer is $1.19 \times 10^{6}\,\text{Nm}^{-2}$)

(ii) **Compressive strain** $= \left(\frac{\Delta l}{l}\right) = \frac{1.25 \times 10^{6}}{1.0 \times 10^{10}}$

$= 1.25 \times 10^{-4}$ ....**(01 mark)**

(if π taken as 3.14 the answer is 1.19×10^{-4})

(iii) 1% of the maximum strain $= 1.75 \times 10^{-2} \times 0.01 = 1.75 \times 10^{-2}$ .... **(01 mark)**

$\therefore \left(\frac{\Delta l}{l}\right)$ in part (ii) above $(1.25 \times 10^{-4}) < 1\%$ of the maximum strain (1.75×10^{-2})

(01 mark)

(In the final answer in part (ii) is wrong, do **not** award this mark)

(iv) Compressive strain on scaled-up person

$$\left(\frac{\Delta l}{l}\right)_{new} = \left[\frac{600 \times 10}{4\pi\,(1.5^2 - 0.5^2) \times 10^{-4}} \Big/ 1 \times 10^{10}\right]$$ .... **(01 mark)**

$$= 2\left[\frac{75 \times 10}{4\pi\,(1.5^2 - 0.5^2) \times 10^{-4}} \Big/ 1 \times 10^{10}\right]$$

$$= 2.5 \times 10^{-4}$$ .... **(01 mark)**

(if π taken as 3.14 the answer is 2.38×10^{-4})

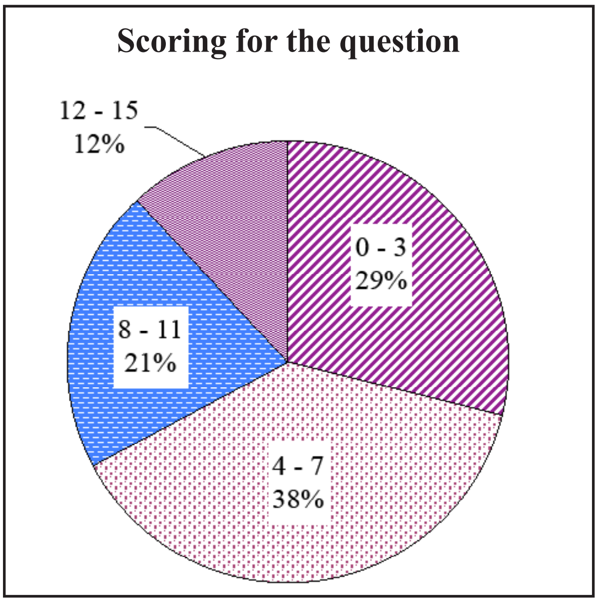
$\left(\frac{\Delta l}{l}\right)_{new}$ in part (c)(iv) above $(2.5 \times 10^{-4}) >$ 1% of the maximum strain(1.75×10^{-4})

$\therefore$ does feel uncomfortable

(If both the answer and the justification are correct) .... **(01 mark)**

(If the final answer in part (iv) is wrong, do **not** award this mark)

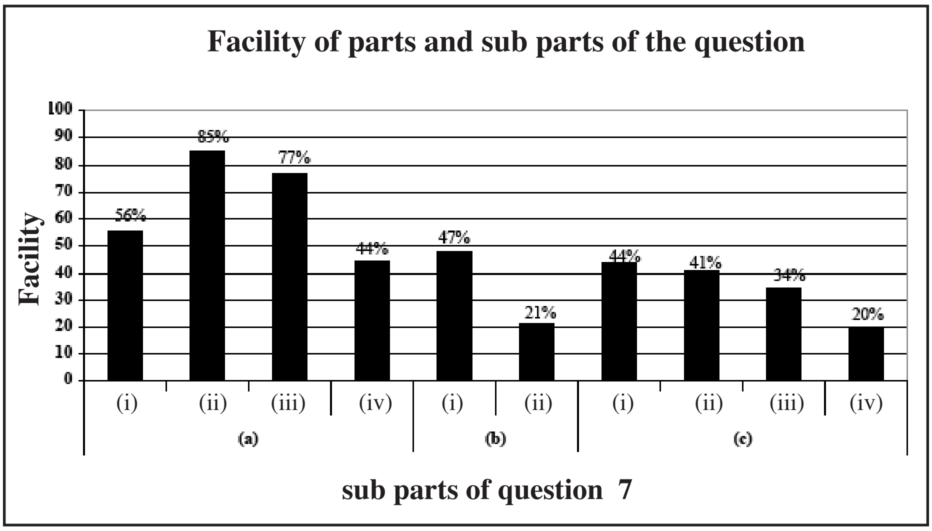
Summary of observations, conclusions and suggestions about answering question 7 :



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

Mark 0-3 class interval 29%
Mark 4-7 class interval 38%
Mark 8-11 class interval 21%
Mark 12-15 class interval 12%

12% of the candidates have obtained 12 or more than 12 marks and 29% of the candidates have obtained 3 or less than 3 marks for this question.



There are 10 sub parts in this question. Out of those, 7 sub parts have exceeded the facility of 40%. Sub part (c) (iv) has the lowest facility and it is 20%. Sub part (a) (ii) has the highest facility of 85%.

72% of the candidates in the sample have selected the question regarding, the section Elasticity from the unit Properties of Matter. The highest facility of 85% was there for sub part (a) (ii). The facility of (a)(i) is 56%. There is a possibility to have a higher facility than this, if the memory regarding the theories is strong enough. The facility of (a) (iii) is 77%. Higher facility of (a) (ii) has increased the facility of (a) (iii). The reason for lowering the facility of (a) (iv) is the inability to realize that the new length due to tensile force is obtained when the extension is added to the initial length.

The inability to realize that the ratio between compressive strain and tensile strain for the same value of stress is equivalent to the inverse of corresponding Young moduli is the reason to have a facility of 47% for sub part (b) (i). The facility of (b) (ii) is as low as 21% due to the low achievement level in understanding the logical situation in the sub part.

The facility of (c) (i) and (c) (ii) have facilities of 44% and 41% respectively due to low achievement level regarding applying and simplification of the equation which is used to calculate the area of the hollow cylinder.

There is a chance to obtain the answer to sub part (c) (iii) using the achievement for the above part. But the facility of it has been reduced up to 34% due to inability to take the advantage.
The facility of sub part (c) (iv) has been reduced up to 20% due to weaknesses in substitution and simplification in calculating the strain.

This question is relatively easy. If the past examination papers were referred earlier the facility of many sub parts would have been increased.

8. (*a*) A long thin conducting straight cylindrical wire A of radius a has a charge per unit length $+\lambda$. Practically this can be done by connecting the wire to a positive potential with respect to ground.

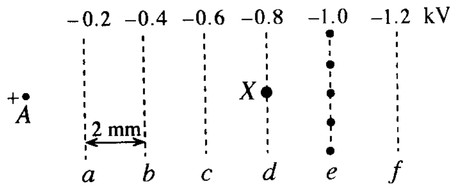
(i) Where does the given charge of the wire physically reside?

(ii) Considering an appropriate Gaussian surface around the wire, show that the magnitude of the intensity of the electric field E at a distance $r\,(\geq a)$ from the axis of the wire is given by $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$, where ε_0 is the permittivity of free space.

(iii) Draw a cross-section of the wire, and draw the equipotential lines around it.

(iv) If $a = 10\ \mu\text{m}$ and $\lambda = 8.1 \times 10^{-8}\ \text{C m}^{-1}$, calculate the magnitude of the intensity of the electric field on the surface of the wire. (Take ε_0 to be $9 \times 10^{-12}\ \text{F m}^{-1}$, and π as 3.)

(v) This wire A is now brought close to a region of a uniform electric field in which the equipotential surfaces are planar and normal to the plane of the paper. The axis of the wire is also normal to the plane of the paper. The dashed lines a, b, c, d, e and f shown in figure represent the cross-sections of the above mentioned equipotential surfaces as seen on the plane of the paper. These dashed lines represent the equipotential lines corresponding to the electric field, and the respective voltages (in kV) of these equipotential lines are also shown in the figure. Distance between any two equipotential lines is 2 mm.



In this arrangement the wire A is connected to a positive potential with respect to the ground, and can be considered as an anode.

(1) Copy the anode and the equipotential lines to the answer script and draw the electric field lines from the positions marked with dots on the equipotential line e up to the anode wire A.

(2) Calculate the intensity of the electric field E_0 between two equipotential lines.

(*b*) Part of an arrangement used for the detection of high energy particles and photons is similar to the one described in part (*a*)(v) above. Suppose that such an arrangement with an anode A having a charge per unit length $+\lambda = 8.1 \times 10^{-8}\ \text{C m}^{-1}$ is housed in a chamber filled with an inert gas (Argon) at atmospheric pressure.

Consider a situation in which a photon enters the chamber and collides with an argon atom at X creating a photoelectron and an argon ion. Such an electron is called a primary electron. The energy needed to create one such electron-ion pair in argon gas is 30 eV. ($1\ \text{eV} = 1.6 \times 10^{-19}\ \text{J}$, charge of an electron $e = 1.6 \times 10^{-19}\ \text{C}$).

(i) Write down an expression for the magnitude of the initial acceleration of the primary photoelectron due to the electric field mentioned in (*a*)(v)(1) above in terms of m, e and E_0, where m and e are the mass and charge of an electron respectively.

(ii) Explain, why the electron moves towards anode A with a drift velocity v_d without accelerating continuously.

(iii) Suppose that the primary electron which started from rest is moving along the electric field mentioned in (*a*)(v)(1) above. If the average distance moved by the primary electron between two successive collisions with argon atoms is $0.5\ \mu\text{m}$, calculate the increase in kinetic energy of the primary electron between two collisions in eV due to the electric field between two collisions, and show that the primary electron having this energy is unable to remove another electron upon colliding with another argon atom. (Consider that the energy required for an electron to remove an electron from an argon atom is 30 eV.)

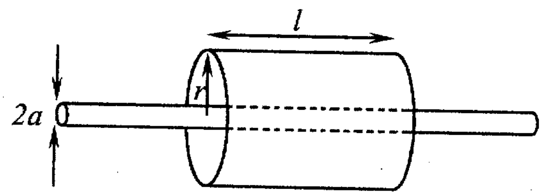
(iv) When this primary electron is close to the anode it experiences a high electric field given by the expression stated in (*a*)(ii) above. Under this condition, the primary electron gains sufficient energy between collisions to create electron-ion pairs and the secondary electrons produced in this manner in turn create more electron-ion pairs before getting collected at the anode. Total number of secondary electrons produced by a single primary electron in this manner is called the **amplification factor** for the gas. Ability to collect charges by the anode wire indicates that it has the property of capacitance. This capacitance is called the detector capacitance. When the charges are collected by the anode, a small voltage is generated across this capacitor.

If the detector capacitance is 5 pF and the voltage generated across this capacitor due to secondary electrons produced by the primary electron is 0.96 mV find the charge collected by the anode.

(v) Hence find the amplification factor for the gas.

(a) (i) The given charge stays on the **surface of the wire**. .... **(01 mark)**

(ii)

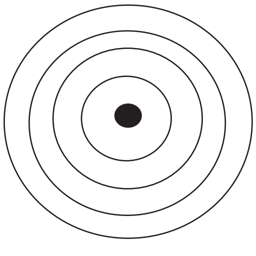


Cylindrical Gaussian surface of radius r and length l (or of unit length) drawn co-axially with the wire .... **(01 mark)**

$$E \times 2\pi r l = \frac{\lambda l}{\varepsilon_0}$$ .... **(01 mark)**

$$E = \frac{\lambda}{2\pi \varepsilon_0 r}$$

(iii)



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

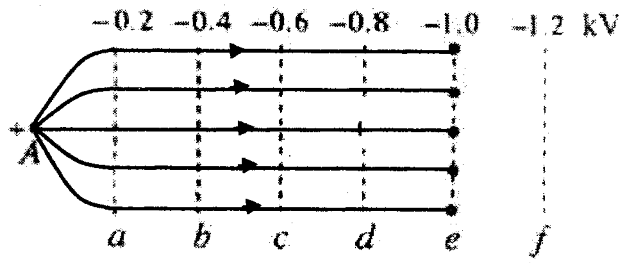
(At least two circles should be shown)

(iv) Using $E = \dfrac{\lambda}{2\pi \varepsilon_0 r}$

When $r = a,\ E = \dfrac{\lambda}{2\pi a \varepsilon_0} = \dfrac{8.1 \times 10^{-8}}{2 \times 3 \times (10 \times 10^{-6}) \times (9 \times 10^{-12})}$

$= 1.5 \times 10^{8}\ \mathrm{Vm^{-1}}$ .... **(01 mark)**

(v) (1)



(Parallel field lies in $a - e$ region) ....**(01 mark)**

(**At least three** lines converging towards wire A) .... **(01 mark)**

(2) $E_0 = \dfrac{\Delta V}{\Delta d} = \dfrac{0.2 \times 10^3}{2 \times 10^{-3}}$

$= 10^5\ \text{Vm}^{-1}$ .... **(01 mark)**

(b) (i) $eE_0 = ma$

$a = \dfrac{eE_0}{m}$ .... **(01 mark)**

(ii) **Electron makes collisions with argon atoms** and thereby loses its kinetic energy.

(01 mark)

(iii) Kinetic energy gained by the electron between two successive collisions

= work done on the electron by the electric field over a distance s

$= eE_0 s$

$= (1.6 \times 10^{-19}) \times (10^5) \times (0.5 \times 10^{-6})$ .... **(01 mark)**

$= \dfrac{8 \times 10^{-21}}{1.6 \times 10^{-19}}$ eV

$=$ 0.05 eV .... **(01 mark)**

0.05 eV < 30 5 eV

Alternative Method :
$= eE_0 s = e \times (10^5)\ \ (0.5 \times 10^{-6})$ V .... **(01 mark)**
$=$ 0.05 eV .... **(01 mark)**

(iv) $Q = CV$ .... **(01 mark)**

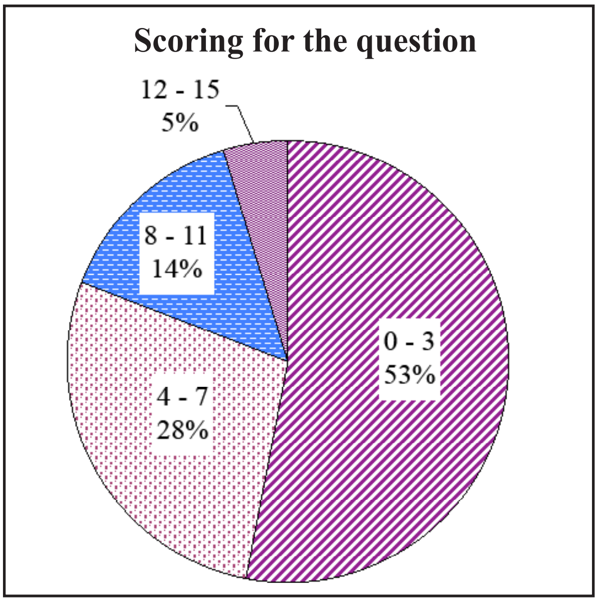
$= (5 \times 10^{-12}) \times (0.96 \times 10^{-3})$

$= 4.8 \times 10^{-15}$ C .... **(01 mark)**

(v) Amplification factor $= \dfrac{4.8 \times 10^{-15}}{1.6 \times 10^{-19}}$

$= 3 \times 10^4$ .... **(01 mark)**

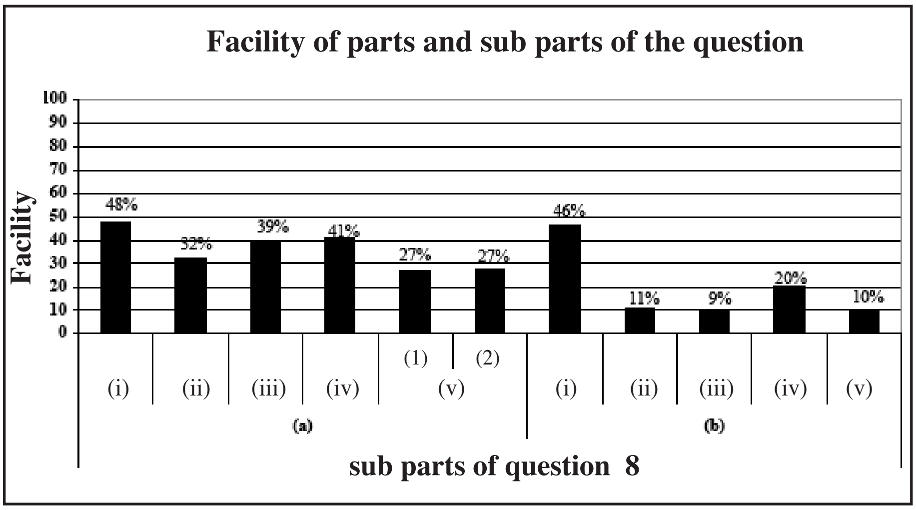
Summary of observations, conclusions and suggestions about answering question 8 :



25% of the candidates have selected this question. It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 53%
Mark 4-7 class interval 28%
Mark 8-11 class interval 14%
Mark 12-15 class interval 5%

5% of the candidates have obtained 12 or more than 12 marks and 53% of the candidates have obtained 3 or less than 3 marks for this question.



There are 11 sub parts in this question. Out of those, 3 sub parts have exceeded the facility of 40%. Sub part (b) (iii) has the lowest facility and it is 9%. Sub part (a) (i) has the highest facility of 48%.

This question is regarding a detector which is based on the principle of electrostatic fields. It has 11 sub parts. The sub parts with highest facilities are sub part (a) (i) with a facility of 48%, sub part (a) (iv) with a facility of 41% and sub part (b) (i) with a facility of 46%. The sub parts with lowest facilities are (b) (ii), (b) (iii), (b) (iv) and (b) (v). They have facilities less than 20% absence of proper understanding has reduced the facility of sub part (a) (v). Facility of (b) (ii) has been reduced due to absence of proper understanding regarding drift velocity. Although the sub parts (b) (iii) and (b) (iv) are easy it seems to be difficult to understand the question. And failing to apply the Gauss' Law is also observed here. Therefore the facility of sub part (a) (ii) was 32%. Although the sub part (a) (iii) is easy improper knowledge on equipotential lines and absence of proper understanding have reduced the achievement level.

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

(A) (*a*) In the circuit shown in figure (1), X is an accumulator of e.m.f. E and internal resistance r. L is an electric lamp connected across AB, and the current through the lamp is I.

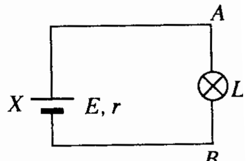


Figure (1)

(i) Show that the power P consumed by the electric lamp can be given as

$$P = EI - I^2 r.$$

(ii) Using the definitions for E and I, explain why the product EI is equal to the power generated by the accumulator.

(iii) Electric lamp in the figure (1) is now replaced by another accumulator of e.m.f. E_1 and internal resistance r_1 as shown in figure (2). $E > E_1$ and the current in the circuit is now I_1.

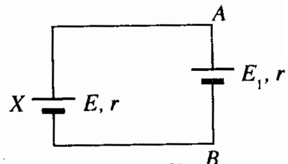


Figure (2)

(1) Show that $EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$.

(2) Physically what quantities do the products EI_1 and $E_1 I_1$ in the above expression represent? Explain your answer.

(*b*) A circuit similar to the one given in figure (2) above can be used to re-charge a run-down rechargeable battery. In this context X is a source capable of delivering a constant power output, and is known as the battery charger. Y represents the run-down battery. Consider such a circuit shown in figure (3).

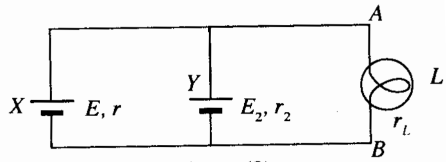


Figure (3)

X is a 12 V battery charger. For the purpose of calculations consider it as a constant power source with e.m.f 12 V, and an internal resistance $r = 2\ \Omega$. L is an indicator lamp of resistance $r_L = 2\ \Omega$ connected across the battery charger. E_2 and r_2 represent the e.m.f. of the battery Y and its internal resistance at a **particular instant** in the charging process. If $r_2 = 1\ \Omega$, and the current through Y is 1 A at that instant,

(i) calculate the e.m.f. E_2 of the battery Y at that instant.

(ii) calculate the power generated by the battery charger, and the power dissipated in r, r_2 and r_L at that instant.

(iii) apply the principle of conservation of energy to the charging process at that instant, and explain what has happened to the excess power generated by the battery charger.

(a) (i) $V_{AB} = E - Ir$

$P = V_{AB} I$

(Both expressions corrects) .... **(01 mark)**

$\therefore \quad P = EI - I^2 r$

(ii) *E.m.f.* E is the work done in bringing a unit (positive) charge (or one coulomb) from the negative electrode which is at a lower potential to the positive electrode which is at a higher potentials (internally). It is stored as energy in the accumulator. .... **(01 mark)**

Current is the charge per unit time

$\therefore$ Energy generated per unit time by the accumulator

$$= E \times \frac{\text{Charge}}{\text{time}} = EI$$

(iii) (1) **Method 1** : Applying Kirchhoff 's law

$E - E_1 = I_1 (r + r_1)$ .... **(01 mark)**

$\therefore\ EI_1 - E_1 I_1 = I_1^2 (r + r_1)$

OR

$EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

Method 2 : Considering accumulator X, $V_A - V_B = V_{AB} = E - I_1 r$

Considering accumulator with e.vm.f. $E_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

Method 3 : Power supplied by the accumulator $X = EI_1 - I_1^2 r$

Power consumed by the accumulator of e.m.f. $E_{1,} = E_1 I_1$

Power dissipated by the internal resistance of the accumulator of e.m.f. E_1 $= I_1^2 r_1$

Argument using the principle of conservation energy........... **(01 mark)**

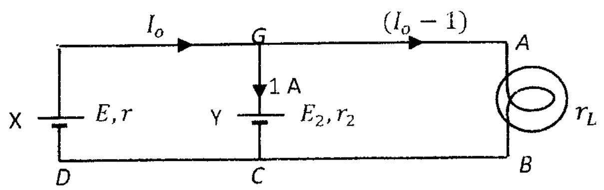
$\therefore\ EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

(2) E_1 represents power generated by the accumulator of e.m.f. E.

$E_1 I_1$ represents the rate at which the work is done by the accumulator X when sending a current of I_1 against the e.m.f. E_1 of the second battery ***OR*** rate at which energy is stored in the accumulator with e.m.f. E_1 **(01 mark)**

(Award this mark if the correct explanation can be found under the (iii)(1) above)

(b) (i)



$E = 12$ V, $r = 2\Omega$
$r_2 = 1\Omega$, $r_L = 2\Omega$

Applying Kirchhoff's equation to the loop *FGCDF*,

$E - E_2 r = Ir + 1 \times r_2$ .... **(01 mark)**

$12 - E_2 r = 2 I_0 + 1$ (Correct substitution) ....**(01 mark)**

Applying Kirchhoff's equation to the loop *FABCDFGA*,

$E = I_0 r + (I_0 - 1) r_L$ .... **(01 mark)**

$12 = 4I_0 - 2$ (Correct substitution) .... **(01 mark)**

$I_0 = \frac{14}{4}$

$\therefore E_2 = 12 - 1 - 2I_0 = 11 - 2 \times \frac{14}{4}$

E.m.f. E_2 of the battery $Y = 4$ V .... **(01 mark)**

(ii) Power generated by the battery charger $= EI_0 = 12 \times \frac{14}{4}$

$= 42$ W .... **(01 mark)**

Power dissipated in r $= \left(\frac{14}{4}\right)^2 2$

$= 24.5$ W .... **(01 mark)**

Power dissipated in r_2 $= 1 \times 1$

$= 1$ W .... **(01 mark)**

Power dissipated in r_L $= \left(\frac{10}{4}\right)^2 2$

$= 12.5$ W .... **(01 mark)**

(iii) Total power dissipated by the circuit elements $= 38$ W

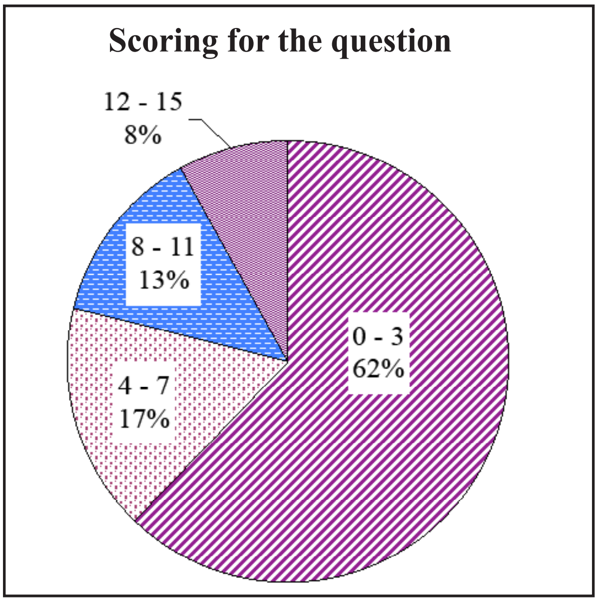
Difference between the generated power and the power dissipated $= 42$ W $- 38$ W

$= 4$ W

(01 mark)

The power is being stored in the battery of e.m.f. E_2 *OR* This power is used to do work against the e.m.f. of battery of e.m.f. E_2 .... **(01 mark)**

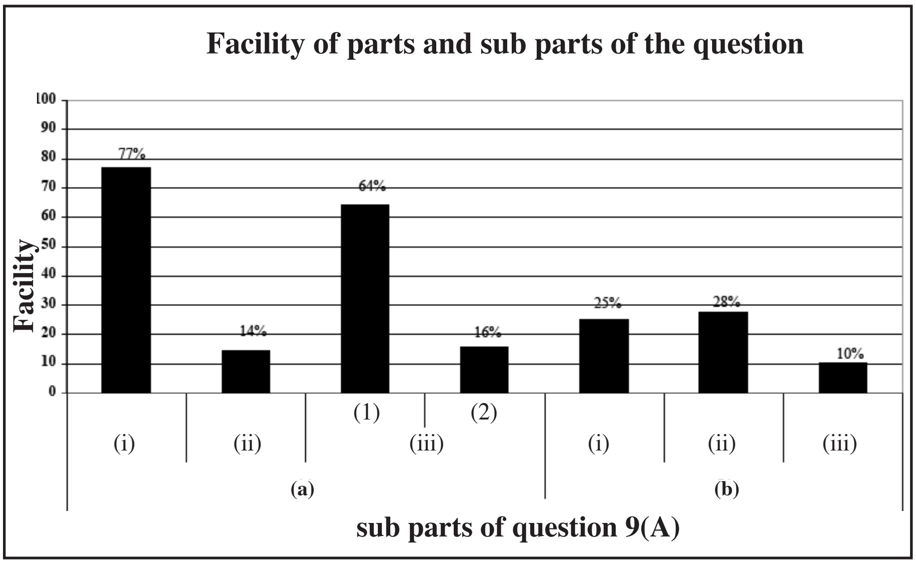
Summary of observations, conclusions and suggestions about answering question 9 (A) :



31% of the candidates have selected the question 9(A). It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 62%
Mark 4-7 class interval 17%
Mark 8-11 class interval 13%
Mark 12-15 class interval 8%

8% of the candidates have obtained 12 or more than 12 marks and 62% of the candidates have obtained 3 or less than 3 marks for this question.



There are 7 sub parts in this question. Out of those, 2 sub parts have exceeded the facility of 60%. Sub part (b) (iii) has the lowest facility and it is 10%. Sub part (a) (i) has the highest facility of 77%.

31% of the students have selected this question. The sub part (a) (i) has the highest facility of 77% and sub part (b) (iii) has the lowest facility of 10%. Some candidates have lost the marks because both the statements are correct. It is essential to teach the students to obtain the expression regarding the power of P in a logical way.

The reason to have a low achievement level for sub parts (a) (ii) and (a) (iii) is not paying due attention on the references which are relevant to the syllabus. It is necessary to direct the students towards the proper definitions of physical quantities. Each sub parts of (b) has a facility less than 30%. The students who could not write expressions using Kirchhoff principle, have lost the marks for other sub parts also. A higher achievement level regarding the applications of Kirchhoff principle can be reached by directing the students towards the transferring of the learnt principles into practical situations.

(**B**) (*a*) Draw current (I) – voltage (V) characteristic for a silicon diode, indicating its forward bias voltage of 0.7 V on the voltage axis.

(*b*) Instead of the characteristic you have drawn under (*a*), hypothetical diode characteristic given in figure (1) is also used frequently in the analysis and design of circuits with silicon diodes. According to the figure (1), current through the diode is zero until its voltage becomes 0.7 V at which the current increases sharply parallel to the I-axis.

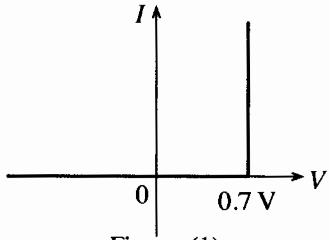


Figure (1)

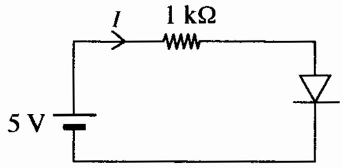


Figure (2)

Use the $I - V$ characteristic given in figure (1) and calculate the current I in the circuit shown in figure (2).

Also use the characteristic given in figure (1) above to answer all the following questions.

(*c*) In the figure (3) shown, D_1 and D_2 are silicon diodes, and the input voltages A and B can have either 5 V or 0 V.

(i) Find the voltage (V_F) at the output F for various combinations of the input voltages and fill in the following table (Copy the table onto your answer script for this purpose)

A(V)	B(V)	V_F(V)
0	0	
5	0	
0	5	
5	5	

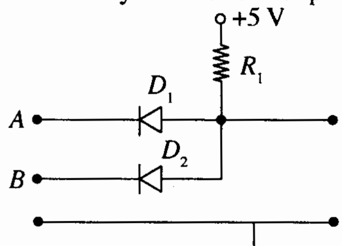


Figure (3)

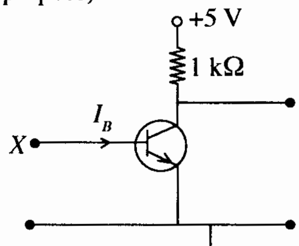


Figure (4)

(ii) As far as F output is considered, if 0.7 V represents binary 0 and 5 V represents binary 1, identify the gate corresponding to the circuit given in figure (3) and write down its truth table.

(iii) Calculate a suitable value for R_1 which will limit the sum of the currents through **both** diodes to 0.5 mA.

(*d*) Suppose the terminal X of the circuit shown in figure (4) is now connected to the output F of the circuit shown in figure (3).

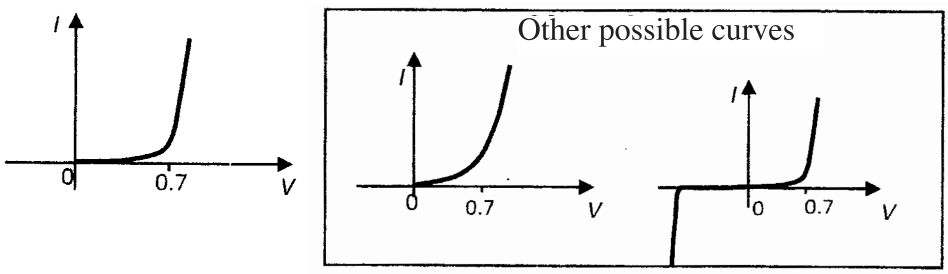
(i) When the inputs A and B represent binary 1, what is the base current I_B?

(ii) Show that the transistor operates as a closed switch under the input conditions given in (*d*)(i) above. Assume that the current gain, β, of the transistor is 50.

(iii) Show that the transistor, however, does **not** operate as an open switch when F in figure (3) represents binary 0.

(iv) With the aid of a circuit diagram, show how you would convert the composite circuit consisting of circuits given in figures (3) and (4) to perform as a NAND gate by inserting another silicon diode at an appropriate place in the circuit given in figure (4) above.

(B)(a) .... **(01 mark)**



(Do not accept the curve given in figure (1) of the question as an answer)

(b) $5 = 10^3 I + 0.7$ .... **(01 mark)**

$I = 4.3 \times 10^{-3}$A *OR* 4.3 mA .... **(01 mark)**

(c) (i) (For fully correct column *F*) .... **(01 mark)**

A(V)	B(V)	F(V)
0	0	0.7
5	0	0.7
0	5	0.7
5	5	5

(ii) It is AND gate .... **(01 mark)**

Truth table (As shown below) .... **(01 mark)**

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

(iii) $R_1 = \frac{5-0.7}{0.5\times10^{-3}}$ .... **(01 mark)**

$= 8.6\ k\Omega$ OR $8.6 \times 10^3\ \Omega$ .... **(01 mark)**

(d) (i) When, A = 1 & B = 1 the two diodes do not conduct. However, since +5 V appears across the series combination of R_1 and the base-emitter junction of the transistor, the the base-emitter junction will become forward biased and therefore the voltage at X will become 0.7 V. .... **(01 mark)**

$\therefore\ I_B = \frac{5-0.7}{8.6\times10^3}$

$= 0.5 \times 10^{-3}$A OR 0.5 mA .... **(01 mark)**

(Accept the answer if a student predicts this value considering the situation given in part (c)(iii) above)

(ii) When $I_B = 0.5$ mA, $\beta I_B = 50 \times 0.5$ mA

$= 25 \times 10^{-3}$A OR 25 mA .... **(01 mark)**

Maximum value of the collector current $(I_C)_{max} = \frac{5\ \text{V}}{10^3\ \Omega}$

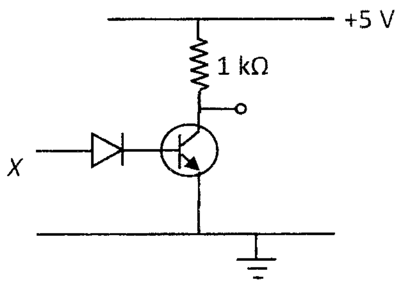
$= 5 \times 10^{-3}$A OR 5 mA .... **(01 mark)**

$\beta I_B > I_C$ OR the transistor is saturated ....**(01 mark)**

(iii) (When F = 0, and if V_F is also 0 V, transistor should operate as an open switch. However, this is not the situation in this case as $V_F = 0.7$ V.)

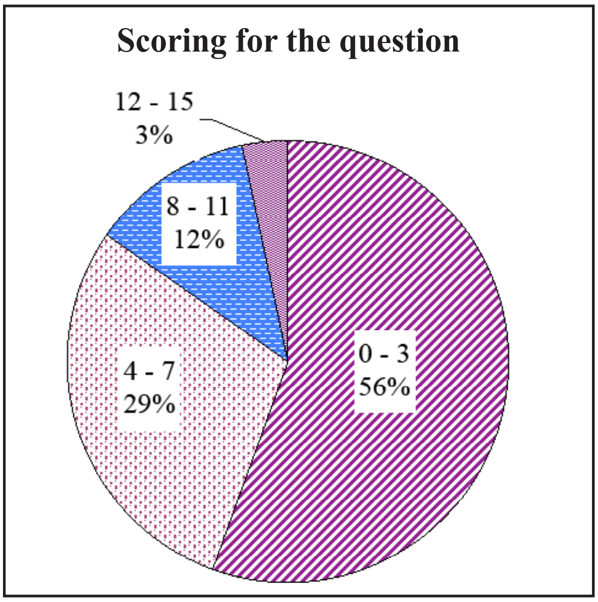
When $V_F = 0.7$ V, , this voltage is sufficient to make the **base-emitter junction of the transistor forward biased** and therefore the transistor does not operate as an open switch. ....**(01 mark)**

(iv) In order to operate the combined circuit as a NAND gate the transistor should operate as an open switch when A ≠ 1 and/or B ≠ 1, so its output is 1 under such situations. This can be done by introducing another diode in the base circuit as shown in the following figure so that the voltage across the base-emitter junction becomes less than 0.7 V; $(= \frac{0.7}{2} = 0.35\ V)$



Diode drawn in the base circuit as shown ....**(01 mark)**

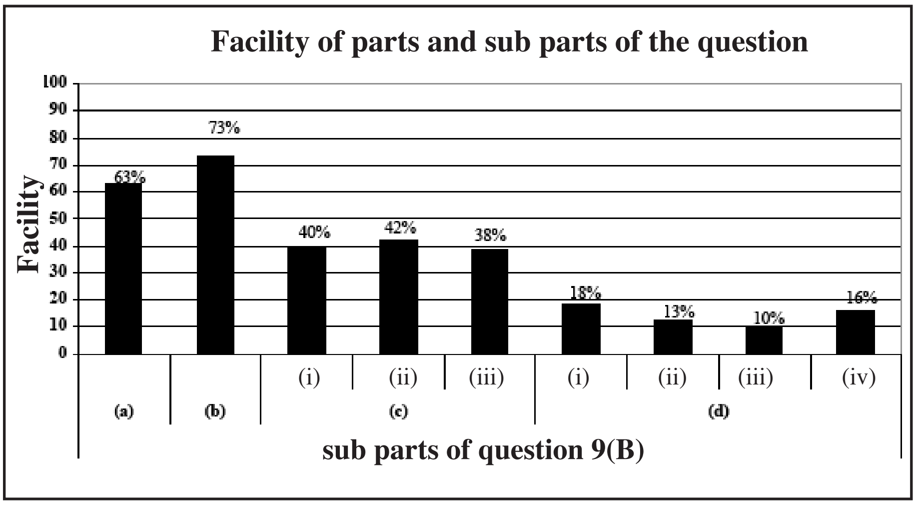
Summary of observations, conclusions and suggestions about answering question 9 (B) :



37% of the candidates have selected the question 9(B). It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 56%
Mark 4-7 class interval 29%
Mark 8-11 class interval 12%
Mark 12-15 class interval 3%

3% of the candidates have obtained 12 or more than 12 marks and 56% of the candidates have obtained 3 or less than 3 marks for this question.



There are 9 sub parts in this question. Out of those, 4 sub parts have exceeded the facility of 40%. Sub part (d) (iii) has the lowest facility and it is 10%. Sub part (b) has the highest facility of 73%.

38% of the students have selected the question, which is from the unit electronics. A highest achievement level is there for sub parts (a) and (b). Those are 63% and 73% respectively. The achievement level is higher, because simple principles have been applied. Achievement levels of sub parts (d) (i), (d) (ii), (d) (iii) and (d) (iv) were less than 20%. Students show a low achievement level in using the theories. It is important to give a sound understanding regarding the fate of output for different combinations of inputs in a transistor circuit. A higher achievement level can be reached by referring the questions which are based on simple and fundamental principles of electronics. If the candidates have practiced the past examination question they would have reached a higher achievement level.

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

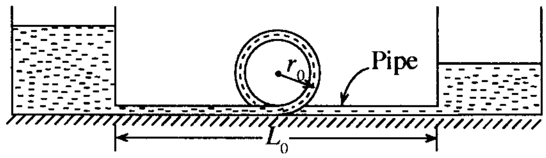
(A) (*a*) A pipe made of copper having a length L_0 at room temperature θ_0 is heated to a temperature θ. Write down an expression for the increase in length of the pipe. Linear expansivity of copper is α.

When answering the following questions always consider steady conditions.

(*b*) An insulated straight copper pipe of length L_0 and internal area of cross-section A_0 at room temperature θ_0 is laid between two oil tanks separated by a large distance to transport heated oil from one tank to the other tank.

If the distance between the tanks is kept fixed at L_0, a compressive stress builds-up in the pipe when heated oil is sent through it. Write down an expression for the maximum temperature θ_M of the oil that can be sent through the pipe without exceeding the compressive elastic limit for copper. Assume that the compressed length corresponding to the elastic limit of copper is ΔL_0.

(*c*) In order to avoid the compression of the pipe as stated in (*b*) and use it to transport oil at a higher temperature θ_H ($>\theta_M$) it was decided to modify the pipe by introducing an additional small circular section made of copper with mean radius r_0 at room temperature θ_0 so that it forms a part of the pipe as shown in the figure.



(i) Explain how such a modification would avoid the compression of the tube with temperature as stated in (*b*) above.

(ii) What is the total length of the pipe at room temperature θ_0?

(iii) Derive an expression for the total length (L_H) of the pipe when oil at temperature θ_H is sent through it.

(iv) Derive an expression for the new mean radius (R_H) of the circular section when oil at temperature θ_H is sent through the pipe. Assume that the shape of the circular section remains as circular.

(v) Derive an expression for the increase in the volume of oil in the pipe at θ_H when compared to the volume at room temperature θ_0.

(vi) If the variations of the area of cross-section of the inlet of the pipe and the density of oil with temperature are negligible, derive an expression for the ratio, $\dfrac{\text{Flow speed of oil at } \theta_H}{\text{Flow speed of oil at } \theta_0}$ in the pipe when its temperature is increased from room temperature θ_0 to θ_H. Assume that the pressure difference of oil between the inlet and outlet of the pipe is constant.

(vii) Even if the pipe is insulated, suppose there is a small **linear** drop in temperature θ_H across the entire length of the pipe. If this drop is $\Delta\theta$, derive an expression for the mean radius of the circular section. Assume that the circular section is located at the middle of the pipe and neglect temperature variation of that section.

(a) $L_\theta = L_0[1 + \alpha(\theta - \theta_0)]$

Increase in length $\Delta L = L_0\alpha(\theta - \theta_0)$ ....**(01 mark)**

(b) $\Delta L_0 = L_0\alpha(\theta_M - \theta_0)$ ....**(01 mark)**

$\theta_M = \frac{L_0\alpha\theta_0 + \Delta L_0}{L_0\alpha}$ OR $= \theta_0 + \frac{\Delta L_0}{L_0\alpha}$ ....**(01 mark)**

(c) (i) The circular section allows the pipe to expand freely by increasing its radius ***OR*** The circular section absorbs the expansion .... **(01 mark)**

(ii) Total length $= L_0 + 2\pi r_0$ .... **(01 mark)**

(iii) $L_H = (L_0 + 2\pi r_0) \times [1 + \alpha(\theta_H - \theta_0)]$ .... **(01 mark)**

(iv) Circumference of the circular section $= L_H - L_0$ ***OR***

$$2\pi r_0[1 + \alpha(\theta_H - \theta_0)] + L_0\alpha(\theta_H - \theta_0)$$ .... **(01 mark)**

$R_H = \frac{L_H - L_0}{2\pi}$ ***OR***

$= \frac{2\pi r_0[1+\alpha(\theta_H-\theta_0)]+L_0\alpha(\theta_H-\theta_0)}{2\pi}$ .... **(01 mark)**

(v) Volume of the pipe at θ_0, $V_\theta = A_0(L_0 + 2\pi r_0)$ .... **(01 mark)**

Length of the pipe at $\theta_H = L_H$

$\therefore$ Volume of the pipe at θ_H, $V_H = A_H L_H = A_0 L_H[1 + 2\alpha(\theta_H - \theta_0)]$ **(01 mark)**

Increase in volume $\Delta V = V_H - V_\theta$

$$\Delta V = A_0 L_H[1 + 2\alpha(\theta_H - \theta_0)] - A_0(L_0 + 2\pi r_0)$$

OR

$$\Delta V = \{A_0[L_0 + 2\pi r_0[1 + \alpha(\theta_H - \theta_0)] + L_0\alpha(\theta_H - \theta_0)] \times [1 + 2\alpha(\theta_H - \theta_0)]\} - \{A_0(L_0 + 2\pi r_0)\}$$

(Any of the above two forms) .... **(01 mark)**

(vi) Volume flow rate of oil at θ_0 $= A_0 v_0$, where v represents the flow speed.

Volume flow rate of oil at θ_H $= A_H v_H = A_0 v_H[1 + 2\alpha(\theta_H - \theta_0)]$

Using continuity equation ; .... **(01 mark)**

$$A_0 v_0 = A_H v_H$$

$$\frac{\text{Flow speed of oil at } \theta_H}{\text{Flow speed of oil at } \theta_0} = \frac{A_0}{A_H}$$

$$= \frac{1}{1+2\alpha(\theta_H - \theta_0)}$$ .... **(01 mark)**

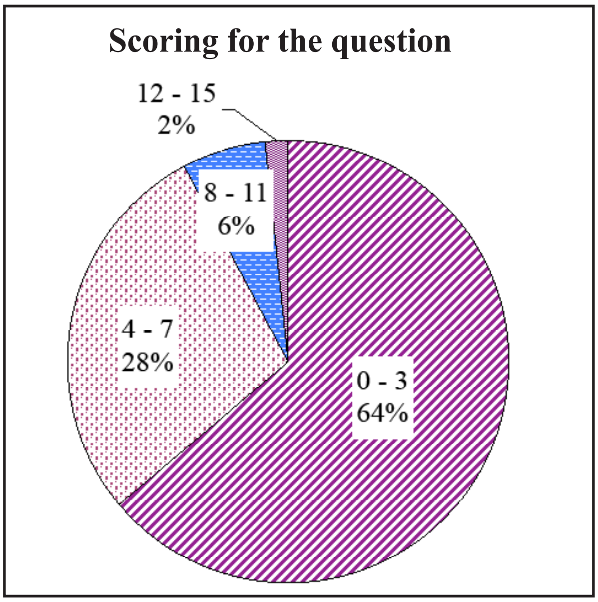
(vii) Mean temperature at the middle of the pipe $= \left(\theta_H - \frac{\Delta\theta}{2}\right)$ *OR*

Identification of $\frac{\Delta\theta}{2}$ as the correct temperature .... **(01 mark)**

Mean radius of the circular section $= \dfrac{2\pi r_0\left[1+\alpha(\theta_H - \frac{\Delta\theta}{2} - \theta_0)\right]+L_0\alpha(\theta_H - \frac{\Delta\theta}{2} - \theta_0)}{2\pi}$

(01 mark)

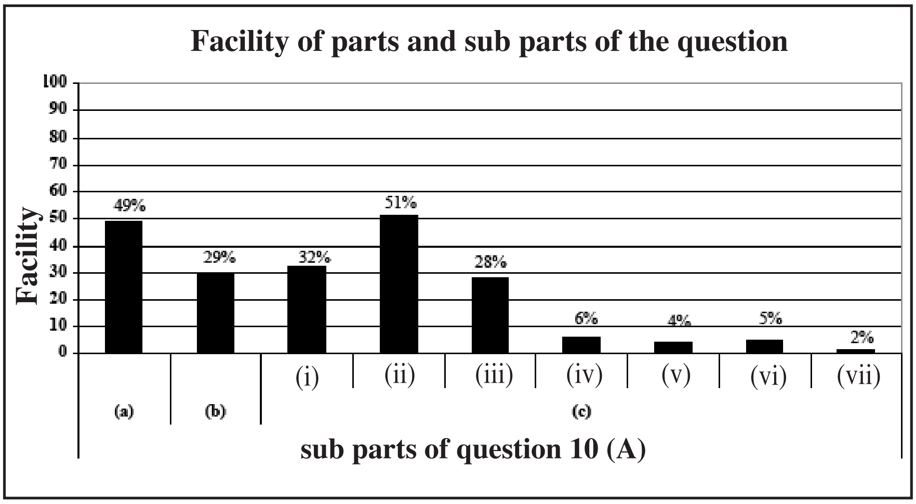
Summary of observations, conclusions and suggestions about answering question 10 (A) :



Since this was not a compulsory question only 25% of the candidates have selected it from the sample. The question carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 64%
Mark 4-7 class interval 28%
Mark 8-11 class interval 6%
Mark 12-15 class interval 2%

2% of the candidates have obtained 12 or more than 12 marks and 64% of the candidates have obtained 3 or less than 3 marks for this question.



There are 9 sub parts in this question. Out of those, 2 sub parts have exceeded the facility of 40%. Sub part (c) (iv) has the lowest facility and it is 2%. Sub part (c) (ii) has the highest facility of 51%.

This is regarding the thermal expansion from the unit thermal physics. 25% of the candidates have selected the question. The highest facility was 51% and the lowest facility was 2%.

Sub part (b) has a facility of 29% because θ_m has not been subjected. Those who did not know have lost the marks. The facility is less than 10% for sub parts(c) (iv), (c) (v), (c) (vi) and (c) (vii) because the students have not understood that the cross section is circular and the diameter is increased. It is important to guide the students to solve problems related to heat conduction through different cross sections.

(**B**) (*a*) Using the Einstein's mass-energy relation, determine the energy equivalence of the atomic mass unit (1 u) in MeV. (1 MeV = 1.6×10^{-13} J, 1 u = 1.66×10^{-27} kg, and speed of light = 3×10^{8} m s^{-1})

(*b*) $^{235}_{92}U$ nucleus undergoes fission when a neutron is absorbed. One of the modes of fission is given in the following reaction.

$$n + {}^{235}_{92}U \longrightarrow {}^{96}_{37}Rb + {}^{138}_{55}Cs + 2n$$

The masses of $^{235}_{92}U$, $^{96}_{37}Rb$, $^{138}_{55}Cs$ and a neutron are approximately, 235.0440 u, 95.9343 u, 137.9110 u and 1.0087 u respectively.

(i) Find the mass loss of the above fission reaction in terms of atomic mass units.

(ii) Hence determine the energy released in the above fission reaction in MeV.

(*c*) In a large nuclear reactor the thermal power generated due to the fission of $^{235}_{92}U$ fuel is 3 200 MW. The corresponding electrical power generated is 1 000 MW. Different modes of fission reactions release different amounts of energy as heat. In these fission reactions the average heat energy generated per fission is 200 MeV.

(i) Determine the efficiency of the nuclear reactor.

(ii) Determine the number of fissions per second (fission rate) at the steady state of the nuclear reactor.

(iii) Hence find the $^{235}_{92}U$ consumption rate in kg per year of the nuclear reactor. (Take Avagadro number as 6.0×10^{23} mol^{-1}.)

(*d*) Natural uranium contains 0.7% of $^{235}_{92}U$ and 99.3% of $^{238}_{92}U$ by weight. Only $^{235}_{92}U$ is required as fuel for the above nuclear reactor to generate electricity. The above reactor requires uranium fuel of 2% enriched uranium (uranium fuel consisting of 2% $^{235}_{92}U$ by weight).

Determine the 2% enriched uranium fuel required to run the 1 000 MW reactor mentioned under (*c*) above for one year.

(*e*) In coal power plants, burning of carbon produces the heat energy required to produce electricity.

$$C + O_2 \longrightarrow CO_2 + 4\ \text{eV}$$

The efficiency of a coal power plant is mostly the same as the efficiency of a nuclear power plant. Determine the amount of carbon in kg required to run a 1 000 MW coal power plant for one year. Assume that the efficiency of the coal power plant is same as the efficiency determined in (*c*)(i) above.
(Molar mass of C = 12 g mol^{-1}).

(B)(*a*) Energy equivalence of 1 u $= (1.66 \times 10^{-27}) \times (3 \times 10^{8})^2$ ....**(01 mark)**

$= 1.494 \times 10^{-10}$ J

$= \dfrac{1.494 \times 10^{-10}}{1.6 \times 10^{-13}}$

= 933.7 MeV (933 MeV – 934 MeV) ....**(01 mark)**

(*b*) (i) mass before the reaction = 1.0087 + 235.0440 u = 236.0527 u

mass after the reaction = 95.9343 + 137.9110 + 2 × 1.0087 u = 235.8625 u .

mass loss = (1.0087 + 235.0440 u) – (95.9343 + 137.9110 + 2 × 1.0087 u) .... **(01 mark)**

mass loss = 0.19 u .... **(01 mark)**

(ii) Energy released = (0.19×934)

= 177.5 MeV (177.2 – 177.5) ....**(01 mark)** (*c*) (i) Efficiency $= \frac{1000}{3200} \times 100$

$= 31.25\%$ .... **(01 mark)**

(ii) Heat energy produced per second $= 3200 \times 10^6$ J

Average heat energy produced per fission $= (200) \times (1.6 \times 10^{-13})$ **(01 mark)**

$= 3.2 \times 10^{-11}$ J

Number of fissions per second $= \frac{3200 \times 10^6}{3.2 \times 10^{-11}}$

$= 10^{20}$ .... **(01 mark)**

(iii) mass of one ^{235}U atom $= \frac{235}{6.0 \times 10^{23}}$ .... **(01 mark)**

$= 39.2 \times 10^{-23}$ g $= 39.2 \times 10^{-26}$ kg

= (39.166 g)

^{235}U consumption rate $= (1 \text{ x } 10^{20}) \times (39.2 \times 10^{-26})$ **(01 mark)**

= (39.166 g)

^{235}U consumption per year $= (3.92 \times 10^{-5}) \times (3600 \times 24 \times 365)$

$= 1.24 \times 10^3$ kg y^{-1} .... **(01 mark)**

$= (1.235 \times 10^3)$

(*d*) 2% enriched uranium fuel required $= (1.24 \times 10^3) / 2\%$

$= 62{,}000$ kg y^{-1} .... **(01 mark)**

= (61150 – 62000)

(*e*) Energy produced by burning one atom of carbon $= 4$ eV $= 4 \times (1.6 \text{ x } 10^{-19})$

$= 6.4 \times 10^{-19}$ J

Carbon consumption rate $= 3200 \times 10^6 / 6.4 \times 10^{-19}$ **(01 mark)**

$= 5.0 \times 10^{27}$ atoms s^{-1}

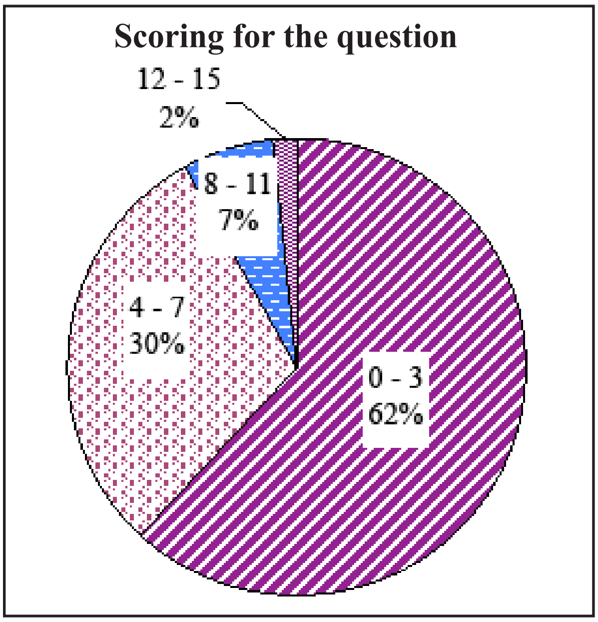
Mass of one carbon atom $= \frac{12}{6.0 \times 10^{23}}$ **(01 mark)**

$= 2.0 \times 10^{-23}$ g $= 2.0 \times 10^{-26}$ kg

Carbon consumption per year $= (5.0 \times 10^{27}) \times (2.0 \times 10^{-26}) \times (3600 \times 24 \times 365)$

$= 3.2 \times 10^9$ kg y^{-1} **(01 mark)**

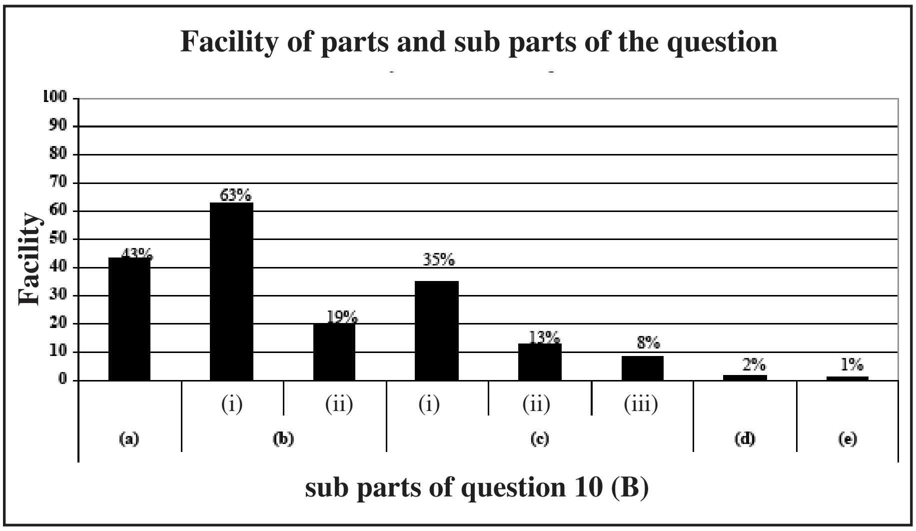
Summary of observations, conclusions and suggestions about answering question 10 (B) :



23% of the candidates have selected the question. It carries 15 marks. The distribution of marks in the class intervals is as follows.

Mark 0-3 class interval 62%
Mark 4-7 class interval 30%
Mark 8-11 class interval 7%
Mark 12-15 class interval 2%

2% of the candidates have obtained 12 or more than 12 marks and 62% of the candidates have obtained less than 4 marks for this question.



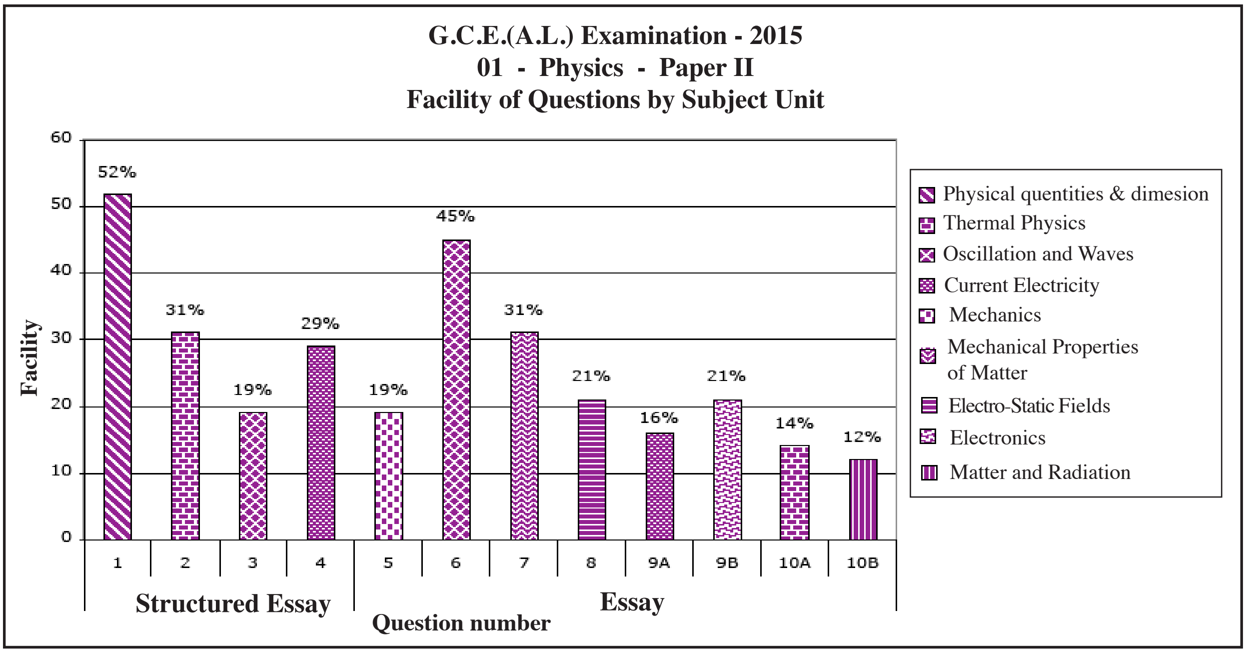
There are 8 sub parts in this question. Out of those, 2 sub parts have exceeded the facility of 40%. Sub part (e) has the lowest facility and it is 1%. Sub part (b) (i) has the highest facility of 63%.

Facility of sub part (a) is 43%. Low achievement level regarding the simplification is the reason. The facility of sub part (b) (i) is 63%. Change in mass has been calculated easily. Since the sub part (b) (ii) is affected by sub part (a) the facility has been reduced up to 19%.

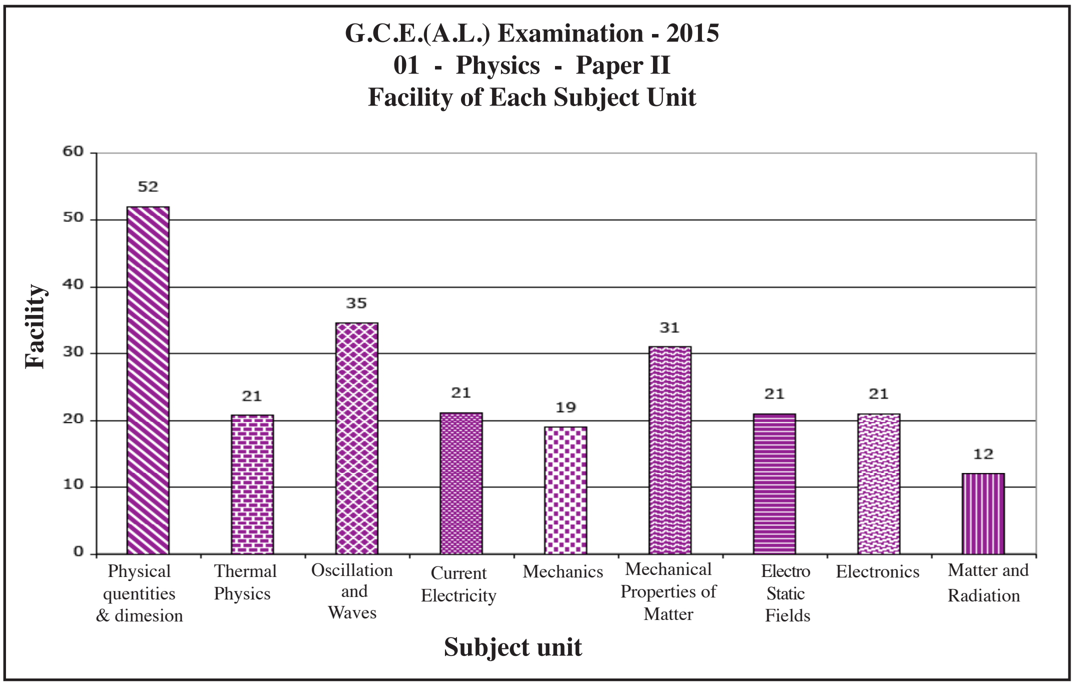
Facility of Sub part (c) (i) is 35%. The facility has been reduced due to not recognizing the information in the paragraph correctly. Facility of sub part (c) (iii) has been reduced up to 8% due to the errors in calculating annual consumption by using the mass of a Uranium atom.

Low achievement level regarding calculation errors and theories have reduced the facility of sub part (d) to a value which is less than 2%. Not having a correct understanding regarding the subject matter has reduced the facility of sub part (e) up to 1%. A higher achievement level can be reached by having correct calculations if a due attention is paid on simplification of simple mathematical operations using logarithm tables.

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



Facility of all questions in in the paper II has a range of 12% to 52%. A facility which is greater than 50% is there only ofor question number 1. The most difficult question for the students is question 10B, which is from the unit matter and radiation. The facility of it is 12%. Although question number 1 from the unit mechanics in part A. Structured Essay has the highest facility out of all four questions, the highest facility has obtained the the question relevant to Oscillations and wave in Eassay part. The facility of it is 45%.



The highest facility of 52% is for the unit Physical Quantities & Dimension unit when the overall facility is considered and question number 1 is the only question from that particular unit. The unit matter and radiation has the lowest facility and the question 10B was from that unit.

Part III

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

3.1. Facts to be considered when answering :

General instructions:

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

Special instructions:

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

Special instructions:

* If the important points are marked while reading the questions containing long paragraphs, the time would be managed efficiently.

* It will be easy to answer within the given time by following the given instructions properly.

* Having understood the fact that the provided space is enough to write a correct answer in structured essay questions, the answering should be done.

* It will be easy to reach the correct answers by using the numerical data given in the question itself when simplifying.

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

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

- The teacher must initiate the teaching process having a clear understanding about the theories and principles in physics and related phenomena which are applied in day-to-day life.

- It can be realised that students' understanding regarding the subject Physics is insufficient When the style of answering is considered for the question paper in G. C. E. (Advanced Level) Examination. Since the principles and concepts have not been formed correctly, the weakness of ability to understand the questions accurately can be seen. If the scientific method is appropriately used in the teaching learning process in the classroom, students can achieve a number of competencies.

- It is easy to direct the students towards the relevant goals by leading the teaching learning process through practical activities.

- It is suitable to use the modern technological resources such as computer software, internet related web sites and instruments such as multi-media projectors to establish the subject knowledge.

- Students must be guided to collect additional knowledge by using supplementary books and resources related to the syllabus.

- The skills of answering questions must be developed in students by making them engaged in working out tutorials

- Students must be trained to give the final answer to the nearest two decimal places correctly where necessary.

- Students must be trained to apply the theoretical knowledge in practical situations

- It is suitable to train the students for the questions containing long paragraphs by doing the past examination questions and by conducting disscusions

- Reading the question paper properly

- Understanding the structure of the question

- Through correct simplifications

- By comparing the answer obtained with the answers given a higher achievement level can be reached. For that
  1. Ability to memorise the theories in each unit
  2. Practicing the exercises
  3. Guidance of the teachers to elaborate the graphs are essential.

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

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