Final Answer Key IOQP 2020-21 Part I (NSEP)
held on 7.2.2021

Question no.	**Set 61**	**Set 62**	**Set 63**	**Set 64**
1	d	b	a	a
2	b	d	d	c
3	c	a	d	c
4	a	a	b	a
5	a	c	c	c
6	a	b	d	c
7	d	a	b	c
8	d	c	c	b
9	b	c	a	d
10	c	a	a	a
11	a	c	a	a
12	b	c	a	c
13	d	c	c	b
14	a	d	c	a
15	a	b	a	d
16	c	c	c	d
17	b	a	c	b
18	a	a	c	c
19	c	a	b	a
20	c	d	d	d
21	a	d	a	b
22	c	b	a	c
23	c	c	c	a
24	c	a	b	a
25	a,c	a,c	a,b,c,d	a,c
26	a,b	a,b	a,b,c,d	a,b
27	a,c	a,c	a,b,c,d	a,c
28	a,b,d	a,b,d	a,c,d	a,b,d
29	a,b,c,d	a,b,c,d	a,c	a,b,c,d
30	a,b,c,d	a,b,c,d	a,b	a,b,c,d
31	a,b,c,d	a,b,c,d	a,c	a,b,c,d
32	a,c,d	a,c,d	a,b,d	a,c,d

Thanks for the suggestions to the answer keys. The expert committee has gone through all the suggestions and recommended the following corrections to answer keys for NSEP- 2017. No more queries and suggestions will be accepted. The list of students above MAS will be announced on December 22nd, 2017.

QP code P160			QP code P161			QP code P162			QP code P163	
Question	Answer Key		Question	Answer Key		Question	Answer Key		Question	Answer Key
5	**b**		11	**b**		9	**d**		2	**d**
37	**d**		18	**b**		10	**b**		18	**b**
46	**d**		50	**d**		18	**d**		43	**b**
60	**b**		59	**d**		48	**b**		52	**d**
68	**a,b,c,d**		61	**a,b,c,d**		70	**a,b,c,d**		69	**a,b,c,d**

NSEP 2018 Answer keys

P160		P161		P162		P163	
A-1		A-1		A-1		A-1	
Qp No	Answer key	qp no	key	qp no	Answer key	qp no	Answer key
1	d	1	d	1	d	1	d
2	c	2	d	2	c	2	c
3	d	3	b	3	d	3	d
4	d	4	c	4	d	4	d
5	d	5	b	5	d	5	d
6	d	6	c	6	d	6	d
7	d	7	a	7	d	7	d
8	b	8	d	8	b	8	b
9	c	9	c	9	c	9	c
10	b	10	d	10	b	10	b
11	c	11	d	11	c	11	c
12	a	12	d	12	a	12	a
13	b	13	b	13	a	13	b
14	c	14	c	14	c	14	c
15	b	15	b	15	d	15	b
16	b	16	b	16	c	16	b
17	b	17	b	17	c	17	b
18	b	18	b	18	c	18	b
19	b	19	b	19	b	19	b
20	a	20	a	20	c	20	a
21	c	21	c	21	b	21	c
22	d	22	d	22	b	22	d
23	c	23	c	23	b	23	c
24	c	24	c	24	b	24	c
25	c	25	c	25	b	25	c
26	a	26	a	26	a	26	a
27	d	27	d	27	d	27	d
28	c	28	c	28	c	28	c
29	d	29	d	29	d	29	d
30	d	30	d	30	d	30	d
31	b	31	b	31	b	31	b
32	d	32	d	32	d	32	d
33	c	33	c	33	c	33	c
34	d	34	d	34	d	34	d

35	b	35	b	35	b	35	b
36	b	36	b	36	b	36	b
37	d	37	d	37	d	37	d
38	c	38	c	38	c	38	c
39	d	39	d	39	d	39	d
40	a	40	a	40	a	40	a
41	b	41	a	41	b	41	b
42	deletd	42	c	42	deleted	42	deleted
43	c	43	c	43	c	43	c
44	a	44	a	44	a	44	a
45	b	45	b	45	b	45	a
46	a	46	deleted	46	a	46	d
47	a	47	c	47	a	47	d
48	c	48	a	48	c	48	c
49	c	49	b	49	c	49	b
50	deletd	50	deleted	50	deleted	50	c
51	a	51	a	51	a	51	b
52	d	52	d	52	d	52	a
53	d	53	d	53	d	53	a
54	c	54	c	54	c	54	c
55	b	55	b	55	b	55	c
56	c	56	c	56	c	56	deleted
57	c	57	c	57	c	57	c
58	a	58	a	58	a	58	a
59	c	59	c	59	c	59	c
60	d	60	d	60	d	60	d
A-2		A-2		A-2		A-2	
61	a,b,c,d	61	a,b,c,d	61	a,b,c,d	61	a,d
62	b,d	62	b,d	62	b,d	62	a,c
63	deletd	63	deleted	63	deleted	63	b,d
64	a,c,d	64	a,c,d	64	a,c,d	64	a,c
65	c,d	65	c,d	65	c,d	65	a,b,c **or** a,b,c,d
66	a,d	66	a,d	66	a,d	66	a,b,c,d
67	a,c	67	a,c	67	a,c	67	b,d
68	b,d	68	b,d	68	b,d	68	deleted
69	a,c	69	a,c	69	a,c	69	a,c,d
70	a,b,c or a,b,c,d	70	a,b,c or a,b,c,d	70	a,b,c or a,b,c,d	70	c,d

Time: 9:00 AM to 10:15 AM

Question Paper Code: 61

Roll No. of Student's														

Write the question paper code mentioned above on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch, and iPad during examination is STRICTLY **PROHIBITED.**
2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **14-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in Indian Olympiad Qualifier in Physics 2021-22 (Part I).
6. Question paper has two parts. In part A1 (Q. No.1 to 24) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as below.

   Q.No.12 a ● c d

   In part A-2 (Q. No. 25 to 32) each question has four alternatives out of which any number of alternative(s) (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternative(s) and fill the appropriate bubble(s), as shown

   Q.No.30 a ● c ●
7. For **Part A-1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A-2,** you get 6 marks if all the correct alternatives are marked and no incorrect. No negative marks in this part.
8. Rough work should be done in the space provided. There are **11** printed pages in this paper
9. Use of **non- programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper & Candidate's copy of OMR for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued) :
You may read the following instructions after submitting the answer sheet.

12. **Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iapt.org.in on the specified format till January 22, 2022.**
13. **The answers/solutions to this question paper will be available on the website: www.iapt.org.in by January 20, 2022.**

14. **CERTIFICATES and AWARDS:**
Following certificates are awarded by IAPT to students, successful in the Indian Olympiad Qualifier in Physics 2021-22 (Part I)
(i) "CENTRE TOP 10 %" To be downloaded from iapt.org.in after 15.03.22
(ii) "STATE TOP 1 %" Will be dispatched to the examinee
(iii) "NATIONAL TOP 1 %" Will be dispatched to the examinee
(iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC – 2022 at HBCSE Mumbai
Certificate for centre toppers shall be uploaded on iapt.org.in
15. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: **www.iapt.org.in** by **February 06, 2022 See the Minimum Admissible Score Clause** on the student's brochure on the web.
16. List of students eligible for evaluation of IOQP 2021-22 (Part II) shall be displayed on www.iapt.org.in by February 10, 2022.

Physical constants you may need….

Mass of electron $m_e = 9.10 \times 10^{-31} kg$	Magnitude of charge on electron $e = 1.60 \times 10^{-19} C$
Mass of proton $m_p = 1.67 \times 10^{-27} kg$	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$
Acceleration due to gravity g = 9.81 ms^{-2}	Permeability of free space $\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
Universal gravitational constant $G = 6.67 \times 10^{-11} Nm^2 Kg^{-2}$	Planck's constant $h = 6.63 \times 10^{-34} Js$
Universal gas constant $R = 8.31\ Jmol^{-1} K^{-1}$	Faraday constant $= 96,500\ Cmol^{-1}$
Boltzmann constant $k = 1.38 \times 10^{-23} J\,K^{-1}$	Rydberg constant $R = 1.097 \times 10^7 m^{-1}$
Stefan's constant $\sigma = 5.67 \times 10^{-8} Wm^{-2} K^{-4}$	Density of water at $4^\circ C$, $\rho = 1.0 \times 10^3 kg\,m^{-3}$
Avogadro's constant $A = 6.023 \times 10^{23} mol^{-1}$	Density of mercury $\rho = 13.6 \times 10^3\ kg\,m^{-3}$
Speed of light in free space $c = 3.0 \times 10^8 ms^{-1}$	Speed of sound in air = 330 ms^{-1}

PHYSICS 2021-22 (Part I) (NSEP 2021 – 22)

Time: 75 Minute **Max. Marks: 120**

Attempt All Thirty Two Questions

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

1. Consider the process of the melting of a spherical ball of ice originally at 0° Assuming that the heat is being absorbed uniformly through the surface and the rate of absorption is proportional to the instantaneous surface area. Which of the following is true for the radius (r) of the ice ball at any instant of time? Assume that the initial radius of the ice ball at $t = 0$ *is* $r = R_0$ and that the shape of the ball always remains spherical during melting. Also assume that L and ρ are respectively the latent heat and density of ice at 0°

(a) radius decreases exponentially with time as $r = R_0 e^{-\frac{kt}{\rho L}}$. Here k is constant

(b) radius decreases exponentially with time as $r = R_0 e^{-\frac{k\rho t}{2L}}$

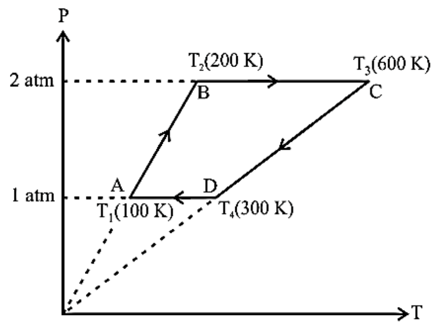
(c) radius of the ice ball decreases with time linearly with a slope $-\frac{k}{\rho L}$

(d) radius of the ice ball decreases with time linearly with a slope $-\frac{k\rho}{2L}$

2. The work done by the three moles of an ideal gas in the cyclic process ABCD shown in the diagram is approximately. Given that

$T_1 = 100\,K$, $T_2 = 200\,K$ and
$T_3 = 600K$, $T_4 = 300\,K$

(a) 7.5 kJ (b) 5.0 kJ
(c) 2.5 kJ (d) Zero

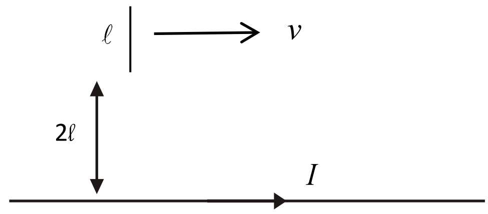


3. The molar specific heat capacity of a certain gas is expressed as $C = C_V + \alpha\frac{P}{T}$.

The equation of state for the process can be written as (α & A are constant)

(a) PV = RT (b) $V = \alpha T^2$ (c) $V^2 = \alpha \ln T$ (d) $T = Ae^{\frac{V}{\alpha}}$

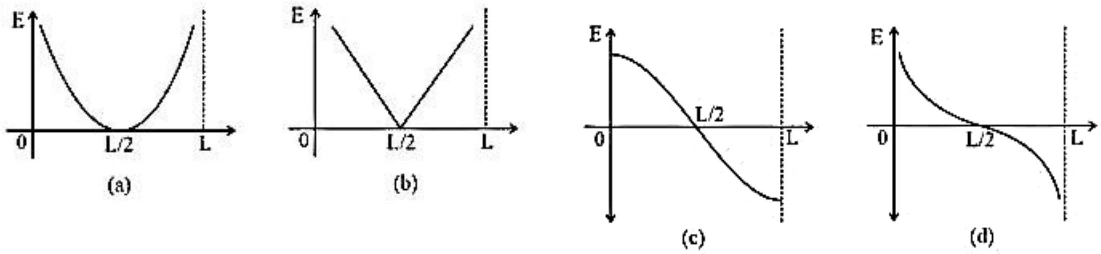
4. A metal bar of length ℓ moves with a velocity v parallel to an infinitely long straight wire carrying a current I as shown in the figure. If the nearest end of the perpendicular bar always remains at a distance 2ℓ from the current carrying wire, the potential difference (in volt) between two ends of the moving bar is



(a) $\frac{\mu_0 I v}{2\pi}$ (b) $\frac{\mu_0 I v}{6\pi}$

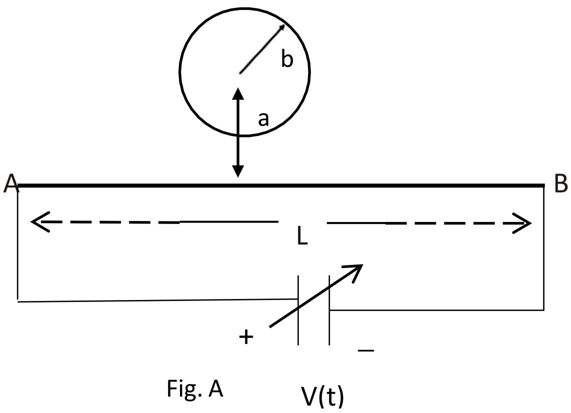
(c) $\frac{\mu_0 I v}{2\pi}\ell$ (d) $\frac{\mu_0 I v}{2\pi}\ell$

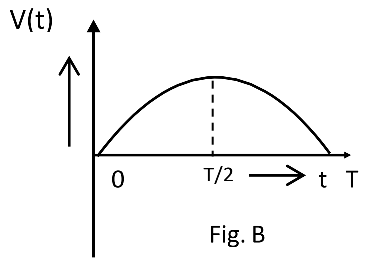
5. Two point charges +Q each are located at (0, 0) and (L, 0) at a distance L apart on the X - axis. The electric field (E) in the region $0 < x < L$ is best represented by



(a) Fig. a (b) Fig. b (c) Fig. c (d) Fig. d

6. A long straight wire AB of length L (L >> a, L >> b) and resistance R is connected to a time varying source of emf V(t). The variation of applied emf V(t) with time is shown in Fig. B. A circular metallic loop of radius r = b is placed coplanar with the current carrying wire with its centre at a distance 'a' from the axis of the wire as shown. The induced current in the loop is





(a) clockwise from 0 to T/2 and anticlockwise from T/2 to T
(b) anticlockwise from 0 to T/2 and clockwise from T/2 to T
(c) clock wise from 0 to T
(d) anticlockwise from 0 to T

7. A simple circuit consists of a known resistance $R_A = 2\ M\Omega$ and an unknown resistance R_B both in series with a battery of 9 volt and negligible internal resistance. When the voltmeter is connected across the resistance R_A, it measures 3 volt but when the same voltmeter is connected across R_B it reads 4.5 volt. The voltmeter measures 9 V across the battery. Considering that the voltmeter has a finite resistance r, the correct option is

(a) $R_B = 3M\Omega$ and $r = 6.0M\Omega$ (b) $R_B = 2.5M\Omega$ and $r = 6.0M\Omega$

(c) $R_B = 4M\Omega$ and $r = 12M\Omega$ (d) $R_B = 4.5M\Omega$ and $r = 6.0M\Omega$

8. The optical powers of the objective and the eyepiece of a compound microscope are 100 D and 20 D respectively. The microscope magnification being equal to 50 when the final image is formed at d = 25 cm i.e., the least distance of distinct vision. If the separation between the objective and the eyepiece is increased by 2 cm, the magnification of the microscope will be

(a) 62 (b) 50 (c) 38 (d) 25

9. A hollow non-conducting cone of base radius R = 50 cm and semi vertical angle of 15^0 has been uniformly charged on its curved surface up to three-fourth of its slant length from base with a surface charge density $\sigma = 2.5\,\mu C/m^2$. The electric field produced at the location of the vertex of the cone is

(a) $\frac{\sigma \ln 2}{2\varepsilon_0}$ (b) $\frac{\sigma \ln 2}{4\varepsilon_0}$ (c) $\frac{\sigma \ln 2}{8\varepsilon_0}$ (d) $\frac{\sigma \ln 2}{16\varepsilon_0}$

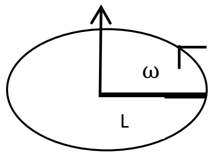
10. A freely falling spherical rain drop gathers moisture (maintaining its spherical shape all the way) from the atmosphere at a rate $\frac{dm}{dt} = kt^2$ where t is the time and m is the instantaneous mass of the drop, the constant $k = 12\,gm/s^3$. If the drop, of initial mass $m_0 = 2gm$, starts falling from rest, the instantaneous velocity of the drop exactly after 5 second shall be (ignore air friction and air buoyancy)

(a) 12.4 ms^{-1} (b) 49.0 ms^{-1} (c) 122.5 ms^{-1} (d) data insufficient

11. Two planets, each of mass M and radius R are positioned (at rest) in space, with their centres a distance 4R apart. You wish to fire a projectile from the surface of one planet to the other. The minimum initial speed for which this may be possible is

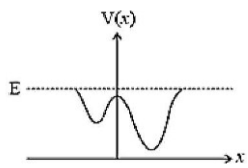
(a) $\sqrt{\frac{2GM}{5R}}$ (b) $\sqrt{\frac{2GM}{3R}}$ (c) $\sqrt{\frac{4GM}{3R}}$ (d) $\sqrt{\frac{3GM}{2R}}$

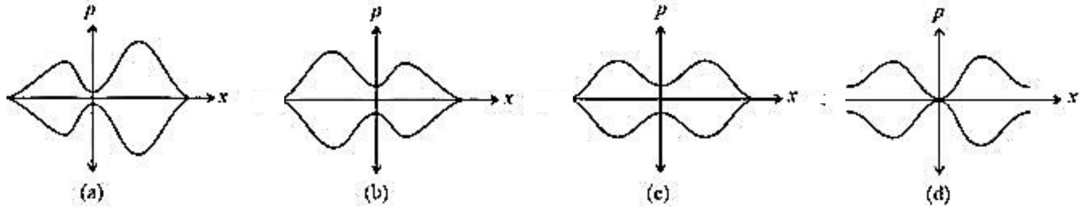
12. A thin uniform metallic rod of length L and radius R rotates with an angular velocity ω in a horizontal plane about a vertical axis passing through one of its ends. The density and the Young's modulus of the material of the rod are ρ and Y respectively.
The elongation in its length is



(a) $\frac{\rho \omega^2 L^3}{6Y}$ (b) $\frac{\rho \omega^2 L^3}{3Y}$
(c) $\frac{\rho \omega^2 RL^2}{2Y}$ (d) $\frac{\rho \omega^2 L^3}{2Y}$

13. Consider a particle of mass m with a total energy E moving in a one dimensional potential field. The potential V(x) is plotted against x in the figure beside.
The plot of momentum – position graph of this particle is qualitatively best represented by





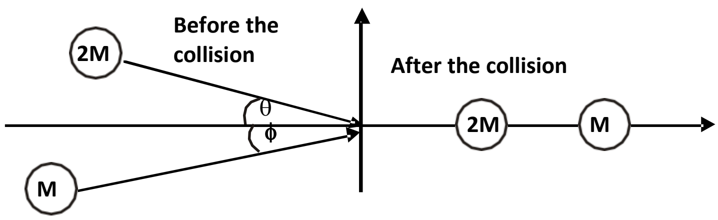
All plots are symmetrical about x - axis

(a) Fig. a (b) Fig. b (c) Fig. c (d) Fig. d

14. Knowing that the parallel currents attract, the inward pressure on the curved surface of a thin walled, long hollow metallic cylinder of radius R = 50 cm carrying a current of i = 2 amp parallel to its axis distributed uniformly over the entire circumference, is

(a) $2.05\times10^{-1}\,Nm^{-2}$ (b) $2.55\times10^{-3}\,Nm^{-2}$ (c) $2.05\times10^{-5}\,Nm^{-2}$ (d) $2.55\times10^{-7}\,Nm^{-2}$

15. Two masses move on a collision path as shown. Before the collision the object with mass 2M moves with a speed v making an angle $\theta=\sin^{-1}\frac{3}{5}$ to the x-axis while the object with mass M moves with a speed $\frac{3}{2}v$ making an angle $\phi=\sin^{-1}\frac{4}{5}$ with the x-axis. After the collision the object of mass 2M is observed to be moving to the right along the x-axis with a speed of $\frac{4}{5}v$. There are no external forces acting during the collision. The correct option is



(a) The velocity of mass M, after the collision, is zero.

(b) The centre of mass is moving along x-axis before the collision.

(c) The velocity of centre of mass after the collision is $\frac{5}{2}v$

(d) The total linear momentum of the system before the collision along x - axis is $\frac{5}{6}Mv$

16. A large hemispherical water tank of radius R is filled with water initially upto a height $h=\frac{R}{2}$. The water starts dripping out through a small orifice of cross section area 'a' at its spherical bottom. The time taken to get the tank completely empty (neglect viscosity) is

(a) $t=\frac{19\pi R^2}{60a}\sqrt{\frac{R}{g}}$ (b) $t=\frac{3\pi R^2}{10a}\sqrt{\frac{R}{g}}$

(c) $t=\frac{17\pi R^2}{60a}\sqrt{\frac{R}{g}}$ (d) $t=\frac{\pi R^2}{4a}\sqrt{\frac{R}{g}}$

17. If Pascal (Pa), the unit of pressure volt (V), the unit of potential and meter (L), the unit of length are taken as fundamental units, the dimensional formula for the permittivity ε_0 of free space is expressed as

(a) $Pa^{-1}V^{2}L^{-2}$ (b) $Pa^{1}V^{-2}L^{2}$ (c) $Pa^{1}V^{2}L^{-2}$ (d) $Pa^{-1}V^{-2}L^{2}$

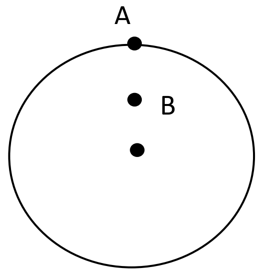
18. A cycle wheel of mass M and radius R fitted with a siren at a point on its circumference, is mounted with its plane vertical on a horizontal axle at about 3 feet above the ground. An observer stands in the vertical plane of the wheel at 100 m away from the axle of the wheel on a horizontal platform. The siren emits a sound of frequency 1000 Hz and the wheel rotates clockwise with a uniform angular speed $\omega = \pi \ rad/\sec$. Initially at t = 0 sec the siren is nearest to the observer and moves downwards. The observer records the highest pitch of sound for the first time after (speed of sound in air is 330 ms^{-1})

(a) 0.30 s (b) 1.8 s (c) 2.3 s (d) 9.8 s

19. On a right angled transparent triangular prism ABC, when a ray of light is incident on face AB, parallel to the hypotenuse BC, it emerges out of the prism grazing along the surface AC. If instead the ray is made incident on face AC, parallel to the hypotenuse CB it gets totally reflected on face AB. The refractive index μ of the material of the prism is

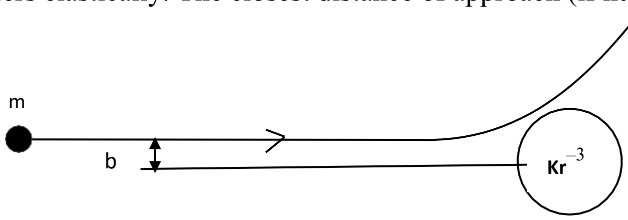
(a) $\mu > \sqrt{2}$ (b) $\sqrt{2} > \mu > \sqrt{\frac{3}{2}}$ (c) $\sqrt{3} > \mu > \sqrt{2}$ (d) $\mu < \sqrt{\frac{3}{2}}$

20. A circular disc of radius R = 10 cm is uniformly rolling on a horizontal surface with a velocity v = 4 ms^{-1} of centre of mass without slipping, the time taken by the disc to have the speed of point A (which lies on the circumference) equal to the present speed of point B (point B lies midway between centre and the point A) is



(a) t = 0.025 s (b) t = 0.036 s
(c) t = 0.046 s (d) t = 0.064 s

21. As shown in the figure, a particle of mass $m = 10^{-10} kg$, moving with velocity $v_0 = 10^5$ m/s approaches a stationary fixed target with impact parameter b from a large distance. If the fixed rigid target has a core with repulsive central force $F(r) = \frac{K}{r^3}$ where constant K > 0 and the particle scatters elastically. The closest distance of approach (if numerically $K = b^2$) is



(a) b (b) $b\sqrt{2}$ (c) $b\sqrt{3}$ (d) 2b

22. If the specific activity of C^{14} nuclide in a certain ancient wooden toy is known to be $\frac{3}{5}$ of that in a recently fallen tree of the same class, the age of the ancient wooden toy is
(The half life of C^{14} is 5570 years)

(a) 5570 years (b) 4105 years (c) 3342 years (d) 2785 years

In questions 23 and 24 mark your answer as

(a) If statement I is true and statement II is true and also if the statement II is a correct explanation of statement I

(b) If statement I is true and statement II is true but the statement II is a not a correct explanation of statement I

(c) If statement I is true but the statement II is false

(d) If statement I is false but statement II is true

23. Statement I: Work done in bringing a charge q from infinity to the center of a uniformly charged non – conducting solid sphere of radius R (with a total charge Q) is zero.

    Statement II: The potential difference between the Centre and the surface of the uniformly charged non – conducting solid sphere of radius R (with a total charge Q) is $\frac{1}{4\pi\varepsilon_0} \times \frac{Q}{2R}$.

24. Statement I: The current flowing through a p-n junction is more in forward bias than that in the reverse bias.

    Statement II: The diffusion current, dominant in forward bias, is more than the drift current, dominant in the reverse bias.

A - 2

ANY NUMBER OF OPTIONS 4, 3, 2 or 1 MAY BE CORRECT

MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED

25. A simple pendulum consisting of a small bob of mass m attached to a massless inextensible string of length ℓ, hanging vertically from the ceiling, is oscillating in a vertical plane with an angular amplitude θ_m such that the maximum tension in its string is three times the minimum tension in the string i.e., $T_{max} = 3T_{min}$. The correct option(s) is/are

(a) The maximum tension in the string is $T_{max} = mg\,(3 - 2\cos\theta_m)$

(b) The maximum tension in the string is $T_{max} = \frac{9}{5}mg$

(c) The maximum velocity of the bob on its way is $v_{max} = 3.96\ ms^{-1}$

(d) The angular amplitude θ_m lies in the range $\frac{\pi}{4} < \theta_m < \frac{\pi}{3}$

26. Two small masses m and M lie on a large horizontal frictionless circular track of radius R. The two masses are free to slide on the track but constrained to move along a circle. Initially the two masses are tied by a thread with a compressed spring between them (spring of negligible length being attached with none of the two masses). The compressed spring stores a potential energy U_0. At a certain time t = 0 the thread is burnt and the two masses are released to run opposite to each other leaving the spring behind. The total mechanical energy remaining conserved. On the circular track the two masses make a head on perfectly elastic collision. Take M = 2m for all calculations. Which of the following option(s) is / are correct?

(a) The angle turned by mass m before the collision is $\theta = 4\frac{\pi}{3}$

(b) The velocity of mass m on the track is $u = \sqrt{\frac{4U_0}{3m}}$

(c) The time taken to collide for the first time is $t_1 = 2\pi R\sqrt{\frac{m}{3U_0}}$

(d) The time taken for the second collision is $t_2 = 2\pi R\sqrt{\frac{2m}{3U_0}}$

27. The electric field component of an electromagnetic wave is expressed as $E = (3j + bk)\times 10^{-3}\sin\left[10^7\left(x + 2y + 3z - \beta t\right)\right]$ in SI units. Taking $c = 3\times 10^8\ ms^{-1}$ as the speed of electromagnetic wave in vacuum, choose the correct option(s)

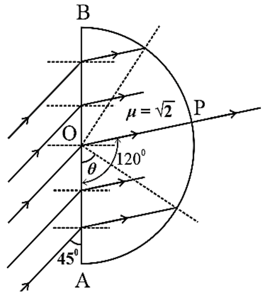
(a) The value of constant beta is $\beta = 3\times 10^8 \times \sqrt{14}$

(b) The value of constant b is b = 2.

(c) The average energy density of the em wave is $U = 6.5\times 10^{-6}\,\varepsilon_0$ in SI units.

(d) The amplitude of magnetic field is $B = 1.20\times 10^{-11}\ Tesla$

28. A parallel beam of light is made incident (as shown) on the flat diametric plane of a transparent semi-circular thin sheet of thickness t (t << R) of refractive index $\mu=\sqrt{2}$ at an angle of 45^0. As a result of refraction, the light enters the semi-circular sheet and comes out at its curved surface.



(a) Light rays come out at the curved surface for values of θ in the range $75^0 \le \theta \le 165^0$.
(b) The range of angle θ is independent of the angle of incidence.
(c) The range of angle θ depends on the refractive index of the material
(d) All the emergent rays of light shall cross the line OP which is a refracted ray at $\theta=120^0$

Here θ is the angle between the vertical diameter AB and the concerned radius of the semicircular sheet of radius R.

29. A certain rod of uniform area of cross section A (A = 1.0 cm^2) with its length = 2 m is thermally insulated on its lateral surface. The thermal conductivity (K) of the material of the rod varies with temperature T as $K=\frac{\alpha}{T}$ where α is a constant. The two ends of the rod are maintained at temperature of $T_1 = 90^\circ$ and $T_2 = 10^\circ$. The correct option(s) is /are

(a) The temperature at 50 cm from the colder end is 17.32°
(b) The temperature at 50 cm from the hotter end is 51.96°
(c) The rate of heat flow per unit area of cross section of the rod is 1.1α in SI units.
(d) The temperature gradient is numerically higher near the hot end compare to that near the cold end.

30. Positronium is a short-lived $(\approx 10^{-9}\text{s})$ bound state of an electron and a positron (a positively charged particle with mass and charge equal (in magnitude) to an electron) revolving round their common centre of mass. If E_0, v_0 and a_0 are respectively the ground state energy, the orbital speed of electron in first orbit and the radius of the first (n = 1) Bohr orbit for Hydrogen atom, the corresponding quantities E, v and a for the positronium are

(a) $E=\frac{E_0}{2}$ (b) $a=a_0$ (c) $a=2a_0$ (d) $E=E_0, v=v_0, a=a_0$

31. A thin double convex lens of radii of curvature $R_1 = 20$ cm and $R_2 = 60$ cm is made-up of a transparent material of refractive index $\mu = 1.5$. Choose the correct option(s)

(a) The focal length of the lens is f = 30 cm when in air.
(b) The lens behaves as a concave mirror of focal length $f_M = 10\ cm$ when silvered on the surface of radius $R_2 = 60$ cm
(c) The lens behave as a concave lens (diverging lens) if the image space beyond $R_2 = 60$ cm radius surface is filled with a transparent liquid of refractive index $\mu = \frac{5}{3}$. The object space prior to the surface of radius $R_1 = 20$ cm is air.
(d) A beam of rays incident parallel to principal axis focuses at 48 cm behind the lens if water $\left(\mu = \frac{4}{3}\right)$ fills the entire space behind the surface of radius $R_2 = 60$ cm. The object space prior to the surface of radius $R_1 = 20$ cm is air.

32. A thick hollow cylinder of height h and inner and outer radii a and b (b > a) made up of a poorly conducting material of resistivity ρ lies coaxially inside a long solenoid at its middle. The radius of the solenoid is larger than b. Throughout the interior of the solenoid, a uniform time varying magnetic field $B = \beta t$ is produced parallel to solenoid axis. Here β is a constant. In this time varying magnetic field

(a) the emf induced at a certain radius r (a < r < b) in the hollow cylinder is $\pi r^2 \beta$
(b) the induced current circulating in the thick hollow cylinder between radii a and b is $i = \frac{\beta h}{4\rho}\left(b^2 - a^2\right)$
(c) the resistance offered to the circulation of current by the thick hollow cylinder is $R = \frac{2\pi\rho}{h \times \ln\frac{b}{a}}$
(d) no electric field is detectable outside the solenoid.

ROUGH WORK

INDIAN OYMPIAD QUALIFIER IN PHYSICS 2021-22 (PART- I)

IOQP 2021-22 PART I (NSEP) Held on March 13, 2022

FINAL ANSWER KEY FOR IOQP 2021-22 PART 1

Question	PAPER CODE 61	PAPER CODE 62	PAPER CODE 63	PAPER CODE 64
1	c	d	b	b
2	b	b	b	a
3	d	c	b	b
4	d	b	b	b
5	d	b	b	a
6	a	b	d	d
7	a	b	a	b
8	a	b	c	c
9	b	b	b	b
10	a	d	d	b
11	b	a	d	b
12	b	c	d	b
13	a	b	a	b
14	d	d	a	b
15	b	d	a	d
16	c	d	b	a
17	b	a	a	c
18	b	a	b	b
19	b	a	b	d
20	b	b	a	d
21	b	a	d	d
22	b	b	b	a
23	d	b	c	a
24	a	a	b	a
25	a, b, c, d	a, c, d	a, b, d	a, c, d
26	a, b, c	a, b, c, d	a, b, c	a, c, d
27	a, c, d	a, c	a, b, c, d	a, b, c, d
28	a, c, d	a, b, d	a, b, c	a, c
29	a, b, c, d	a, b, c	a, c, d	a, b, d
30	a, c	a, b, c, d	a, c, d	a, b, c
31	a, b, d	a, b, c	a, b, c, d	a, b, c, d
32	a, b, c	a, c, d	a, c	a, b, c

IOQP 2021-22 PART I (NSEP – 2021-22) Solution– 61

1. The instantaneous rate of absorption of heat is $\frac{dQ}{dt} \propto 4\pi r^2 = k4\pi r^2$ Also $\frac{dQ}{dt} = -L\frac{dm}{dt}$ So $-L\frac{dm}{dt} = k4\pi r^2$ *or* $-L\frac{d}{dt}\left(\frac{4\pi}{3}r^3\rho\right) = k4\pi r^2$ or $\frac{dr}{dt} = -\frac{k}{\rho L} \Rightarrow \int_{r_0}^{r} dr = -\frac{k}{\rho L}\int_0^t dt \Rightarrow r = r_0 - \frac{k}{\rho L}t$ or $r = -\frac{k}{\rho L}t + r_0$ which is a straight line with negative slope $= -\frac{k}{\rho L}$ where k is constant. **Ans: c**

2. The process from A to B is isochoric $\because P \propto T$ means the volume is constant. Therefore the work done $dW_{AB} = PdV = 0$ From B to C the process is isobaric so work done is $dW_{BC} = PdV = nRdT = 3\times R\times(600-200) = 1200R$ .CD is again isochoric process so work done $W_{CD} = 0$. Further the process from D to A is isobaric means P constant and work done is $dW_{DA} = PdV = nRdT$ or $dW_{DA} = 3\times R(100-300) = -600R$. Thus the total work done is $W = 1200R - 600R = 600R = 4986J = 4.986kJ = 5.0kJ$ **Ans: b**

3. From first law of thermodynamics $dQ = dU + dW \Rightarrow C\,dT = C_V\,dT + P\,dV$. Given that $C = C_V + \alpha\frac{P}{T}$ Substituting the value we get $\left(C_V + \alpha\frac{P}{T}\right)dT = C_V dT + PdV \Rightarrow \alpha\frac{dT}{T} = dV$ on integration we get $\alpha\times \ell nT = V + \text{constant}$ or $T = Ae^{V/\alpha}$ **Ans: d**

4. The magnetic field produced by a current carrying conductor at a distance x is $B = \frac{\mu_0 I}{2\pi x}$
Therefore the induced emf in a conductor of length dx moving with velocity v is
$d\varepsilon = -\ell Bv = -\frac{\mu_0 I}{2\pi x}v\,dx.$ Total emf produced in the present problem is

$$\varepsilon = -\int_{2\ell}^{3\ell}\frac{\mu_0 I}{2\pi x}v\,dx = -\frac{\mu_0 I}{2\pi}v\int_{2\ell}^{3\ell}\frac{dx}{x} = \frac{\mu_0 I}{2\pi}v \times \ln 1.5$$ **Ans: d**

5. Since both the charges are positive, the electric field at any point between them is $E = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{x^2} - \frac{Q}{(L-x)^2}\right]$ This will be positive for $0 < x < \frac{L}{2}$ and negative for $\frac{L}{2} < x < L$ as shown in figure d. The curve is a $\frac{1}{x^2}$ type. **Ans d**

6. When the current flows in the wire along AB, the magnetic field in the circular loop is directed outward perpendicular to the plane of the paper. During the increase of current i.e., from 0 to T/2, the induced current in the loop is clockwise while during the decrease of current i.e., T/2 to T the induced current shall be anticlockwise. Hence the answer is a.
Ans a

7. The $2.0M\Omega$ resistance is connected in series with R_B and the cell. When we connect the voltmeter of resistance $r\,M\Omega$ in parallel to $2.0M\Omega$ we get $3=\frac{9}{\frac{2r}{r+2}+R_B}\times\frac{2r}{r+2}$

$\Rightarrow 2r+R_B\,(r+2) = 6r \Rightarrow R_B=\frac{4r}{r+2}$ When we connect the same voltmeter in parallel with R_B we get $4.5=\frac{9}{2+\frac{rR_B}{r+R_B}}\times\frac{rR_B}{r+R_B}$ $\Rightarrow 2(r+R_B)+rR_B=2rR_B \Rightarrow R_B=\frac{2r}{r-2}$ Comparing the result

$\frac{4r}{r+2}=\frac{2r}{r-2} \Rightarrow r=6$ Thus $r=6M\Omega$ and $R_B=3\ M\Omega$ **Ans: a**

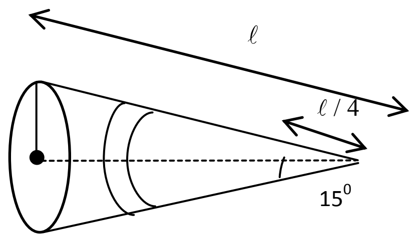
8. The magnifying power of a compound microscope when the final image is formed at D, the least distance of distinct vision is $MP=\frac{V_0}{U_0}\left(1+\frac{D}{f_e}\right)$ Now as per the given conditions

$50=\frac{V_0}{U_0}\left(1+\frac{25}{5}\right)\Rightarrow\frac{V_0}{U_0}=\frac{25}{3}$ Now for the objective lens $\frac{1}{V_0}-\frac{1}{-U_0}=\frac{1}{f_0} \Rightarrow 1+\frac{V_0}{U_0}=\frac{V_0}{f_0}$

comparing the two, we get $V_0=\frac{28}{3}cm.$ Increasing the length of microscope by 2 cm, Then

$V_0=\frac{28}{3}+2=\frac{34}{3}cm$ In the new situation $1+\frac{V_0'}{U_0'}=\frac{V_0'}{f_0}=\frac{34}{3}\Rightarrow\frac{V_0'}{U_0'}=\frac{31}{3}$ The magnifying power therefore now becomes $MP=\frac{31}{3}\left(1+\frac{25}{5}\right)=62$ **Ans: a**

9. Let us consider an elementary ring of width $d\xi$ at a slant distance ξ from the vertex of the cone. The charge on the circular ring shall be $dq=2\pi\xi\sin\theta\,d\xi\times\sigma$. The electric field produced by this elementary ring at the vertex of the cone is $dE=\frac{1}{4\pi\varepsilon_0}\times\frac{2\pi\xi\sin\theta\,d\xi\times\sigma\times\xi\cos\theta}{\xi^3}$ Thereby the electric field



E at the vertex shall be $E=\frac{\sigma}{4\varepsilon_0}2\sin\theta\cos\theta\int_{l/4}^{l}\frac{d\xi}{\xi}\Rightarrow E=\frac{\sigma}{4\varepsilon_0}\sin2\theta\{\ln\xi\}_{l/4}^{l}$

$\Rightarrow E=\frac{\sigma}{8\varepsilon_0}\times2\ln2=\frac{\sigma}{4\varepsilon_0}\ln2$ **Ans: b**

10. According to the Newton's Second Law $F = \frac{dp}{dt}$. In the present case the rain drop is attracted by the earth so at any instant, $mg = \frac{d}{dt}(mv) \Rightarrow mg = m\frac{dv}{dt} + v\frac{dm}{dt} \quad or \quad g = \frac{dv}{dt} + \frac{v}{m}\frac{dm}{dt}$

Given that $\frac{dm}{dt} = kt^2 \Rightarrow m = \frac{kt^3}{3} + m_0$ where m_0 is initial mass. Further

$$g = \frac{dv}{dt} + \frac{v}{\frac{kt^3}{3} + m_0} \times kt^2 \;\Rightarrow \frac{dv}{dt} = g - \frac{3kt^2}{3m_0 + kt^3} \times v \Rightarrow \frac{dv}{dt} + \left(\frac{3kt^2}{3m_0 + kt^3}\right)v = g \text{ or}$$

$$\Rightarrow \left(3m_0 + kt^3\right)dv + v3kt^2 dt = g\left(3m_0 + kt^3\right)dt \text{ or} \Rightarrow d\left\{\left(3m_0 + kt^3\right)v\right\} = g\left(3m_0 + kt^3\right)dt$$

Integrating we get $\left(3m_0 + kt^3\right)v = \left(3m_0 gt + \frac{gkt^4}{4}\right)_0^t$ or

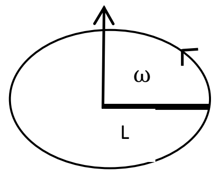
$$v = g\frac{12m_0 t + kt^4}{4\left(3m_0 + kt^3\right)} = \frac{1905}{1506}g = 12.4\,ms^{-1}$$ **Ans: a**

11. Two planets of mass M and radius R each are separated by distance 4R. A mass m has to be thrown from Planet A so as just to reach Planet B. For this we need to throw the mass so that it just reaches the midpoint then after it will be attracted by B. The potential energy of the mass m on the surface of the planet A is $U_A = -\frac{GMm}{R} - \frac{GMm}{3R} = -\frac{4GMm}{3R}$ and the potential energy at the midpoint between the two planets is $U_{Mid} = -\frac{GMm}{2R} - \frac{GMm}{2R} = -\frac{GMm}{R}$

Hence the energy needed to project the body is

$$\frac{1}{2}mv^2 = \left(-\frac{GMm}{R}\right) - \left(-\frac{4GMm}{3R}\right) \Rightarrow v = \sqrt{\frac{2GM}{3R}}$$ **Ans: b**

12. When the rod rotates about a vertical axis through one of its ends, every pointon the rod experiences a centrifugal force. If we consider a small length dx of mass $\lambda\,dx$ at a distance x from the axis where $\lambda = \frac{M}{L} = \frac{\pi R^2 L\rho}{L} = \pi R^2\rho$,



The outward pull on this length x is $= \frac{\lambda\,dx\,\omega^2\,x^2}{x} = T(say)$

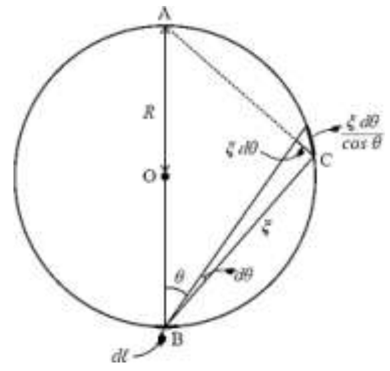
This force will cause an elongation in the rod, because of its elasticity.

The elongation may be given by $d\xi = \frac{T\,x}{AY} = \frac{\lambda\,dx\,\omega^2\,x}{\pi R^2 Y}.x = \frac{\rho\omega^2}{Y}.x^2\,dx.$

The total elongation in the rod is therefore $\int d\xi = \frac{\rho\omega^2}{Y}\int_0^L x^2\,dx = \frac{\rho\omega^2 L^3}{3Y}.$

Ans: b

13. Since the total energy is fixed, the kinetic energy so to say the magnitude of the momentum will be large where ever the potential energy is less and vice versa. Further the momentum $p = \pm\sqrt{2m\times(KE)} = \pm\sqrt{2m\times(E-V)}$. Here (E-V) is the kinetic energy of the particle. The curve for momentum will be symmetric about x axis so curve a.
Ans: a



14. In a hollow metallic cylinder current is sent parallel to its axis along the entire curved surface. Let us consider a thin strip of width dl on the surface and along the length of the cylinder at a point B and another parallel strip of width $\frac{\xi d\theta}{\cos\theta}$ at the end of the chord of length ξ at angle θ . If I be the current through the metallic cylinder then the current per unit width shall be $j = \frac{I}{2\pi R}$. Thereby the current through the two parallel strips separated by ξ shall be $jdl\ and\ j\frac{\xi d\theta}{\cos\theta}$ respectively.

The force of attraction between these two parallel wires shall thus be $F = \frac{\mu_0}{2\pi}\frac{jdl\times j\xi d\theta}{\xi\cos\theta}\ Nm^{-1}$. Component of this force towards the centre will add togive resultant inward force then dividing by dl and integrating over θ within the limits $-\frac{\pi}{2} \le \theta \le \frac{\pi}{2}$ we obtain force per unit surface of the hollow cylinder. Thusthe inward force per unit surface area is

$$= \sum F\cos\theta = \frac{\mu_0 j^2}{2\pi}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} d\theta = \frac{\mu_0 j^2}{2} = \frac{\mu_0}{2}\left(\frac{I}{2\pi R}\right)^2 = 2.55\times10^{-7}\,Nm^{-2}$$

Ans: d

15. By the principle of conservation of momentum along x-direction $2Mv\cos\theta + M\frac{3}{2}v\cos\phi = 2M\times\frac{4}{5}v + MV_x$ where V_x is the velocity of mass M in x direction after the collision. Substituting the values $2Mv\times\frac{4}{5} + M\frac{3}{2}v\times\frac{3}{5} = 2M\times\frac{4}{5}v + MV_x \Rightarrow V_x = \frac{9}{10}v$

In y-direction the momentum conservation yields $-2Mv\sin\theta + M\frac{3}{2}v\sin\phi = 2M\times0 + MV_y$

substituting the values $-2Mv\frac{3}{5} + M\times\frac{3}{2}v\times\frac{4}{5} = 0 + MV_y \Rightarrow V_y = 0$ means no velocity in y-direction. Hence the centre of mass moves along x-direction. The velocity of centre of mass after the collision is $V_{xCM} = \frac{2M\times\frac{4}{5}v + M\times\frac{9}{10}v}{3M} = \frac{25}{30}v = \frac{5}{6}v$ and not $\frac{5}{2}v$ Also the linear momentum before collision is $\frac{25}{10}Mv = \frac{5}{2}Mv$ and not $\frac{5}{6}Mv$ **Ans: b**

16. Let us consider that the height of the liquid surface in the hemispherical bowl is h at a certain time t. The radius of water surface at this time shall be $=\sqrt{R^2-(R-h)^2}$ So the surface area of the liquid at this time will be $=\pi\left\{R^2-(R-h)^2\right\}=\pi\left(2Rh-h^2\right)$ Further considering that the liquid height falls through dh in time dt, the volume of liquid flowing out per second can be written as $-\pi\left(2Rh-h^2\right)\dfrac{dh}{dt}=va=a\sqrt{2gh}$ Thereby $dt=-\dfrac{\pi}{a\sqrt{2g}}\left(2Rh^{1/2}-h^{3/2}\right)dh$ integrating we get $\int_0^t dt=-\dfrac{2\pi R}{a\sqrt{2g}}\int_{R/2}^{0}h^{1/2}dh+\dfrac{\pi}{a\sqrt{2g}}\int_{R/2}^{0}h^{3/2}dh\Rightarrow t=\dfrac{17\pi R^2}{60a}\sqrt{\dfrac{R}{g}}$

Ans: c

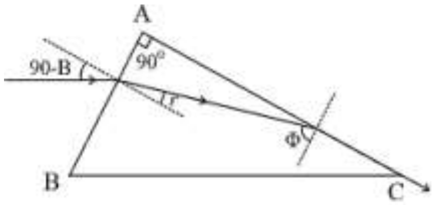
17. To obtain dimensional formula for ε_0 let us express Coulomb's law as

$$F=\frac{1}{4\pi\varepsilon_0}\times\frac{q_1q_2}{r^2}=4\pi\varepsilon_0\left(\frac{1}{4\pi\varepsilon_0}\times\frac{q_1}{r}\right)\left(\frac{1}{4\pi\varepsilon_0}\times\frac{q_2}{r}\right)\Rightarrow\left(\frac{F}{4\pi r^2}\right)r^2\cong\varepsilon_0\left(\frac{1}{4\pi\varepsilon_0}\times\frac{q_1}{r}\right)\left(\frac{1}{4\pi\varepsilon_0}\times\frac{q_2}{r}\right)$$

$\Rightarrow Pa\times L^2=\varepsilon_0V^2\Rightarrow\varepsilon_0=(Pa)^1L^2V^{-2}$ **Ans: b**

18. The observer will record the maximum frequency $\upsilon'=\dfrac{v}{v-v_s}\times\upsilon$ when the sound produced by the siren, in the top most point of the circumference of the wheel, reaches the listener. This sound will reach the listener in time $t=\dfrac{100}{330}=0.303\,\text{s}$ after being produced. Also the wheel itself will take time $t_0=\dfrac{3}{4}\times\dfrac{2\pi}{\omega}$ substituting $\omega=\pi$ we get $t_0=\dfrac{3\pi}{2\pi}=1.5\ s$ Hence the total time is $t+t_0=0.303+1.5=1.803\,s$ **Ans: b**

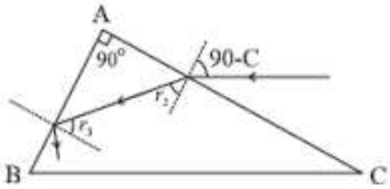
19. For a ray of light incident on side AB parallel to the base, we can write that the refractive index



$$\mu = \frac{\sin(90-B)}{\sin r} = \frac{\cos B}{\sin r} \text{ or } \mu \sin r = \cos B....(1)$$

Also $r+\phi = 90$ or $\sin r = \sin(90-\phi) = \cos\phi = \sqrt{1-\sin^2\phi}$

or $\sin r = \sqrt{1-\frac{1}{\mu^2}} = \sqrt{\frac{\mu^2-1}{\mu^2}}$ or $\mu \sin r = \sqrt{\mu^2-1}$ ...(2)



From (1) and (2) $\cos B = \sqrt{\mu^2-1}$

or $\cos^2 B = (\mu^2-1)$....(3)

Next the ray is incident parallel to base on the side AC.

Here also $r_2 + r_3 = 90$ and since $r_3 > \phi$ i.e.the critical angle Now using $r_2 = 90 - r_3$ and

$\mu = \frac{\sin(90-C)}{\sin r_2} = \frac{\sin(90-C)}{\sin(90-r_3)} = \frac{\cos C}{\cos r_3}$ or $\mu \cos r_3 = \cos\ C = \cos(90-\mathrm{B}) = \sin \mathrm{B}$ This in turn gives $\mu^2(1-\sin^2 \mathrm{r}_3) = \sin^2 B$ .... (4) adding equation (3) and (4)

$$\left(\mu^2 - \mu^2\sin^2 r_3\right) + \mu^2 - 1 = 1 \Rightarrow 2\left(\frac{\mu^2-1}{\mu^2}\right) = \sin^2 r_3....(5)$$

Further angle $r_3 > \phi$ or $\sin r_3 > \sin\phi$

$\Rightarrow \sqrt{2\left(\frac{\mu^2-1}{\mu^2}\right)} > \sin\phi \Rightarrow 2\left(\frac{\mu^2-1}{\mu^2}\right) > \frac{1}{\mu^2} \Rightarrow \mu^2 - 1 > \frac{1}{2} \Rightarrow \mu^2 > \frac{3}{2} \Rightarrow \mu > \sqrt{\frac{3}{2}}$ Also

$r + \phi = 90\ but\ r < \phi$ So essentially $\phi > 45$ or $\sin\phi > \sin 45\ or\ \frac{1}{\mu} > \frac{1}{\sqrt{2}} \Rightarrow \mu < \sqrt{2}$ Thus we can conclude that $\sqrt{\frac{3}{2}} < \mu < \sqrt{2}$ **Ans: b**

20. Under the conditions of pure rolling of the disc, the velocity of the point A (at the top) on the circumference is $v + \omega R = 2v$ where as the velocity of point B at half the radius is $v + \omega\frac{R}{2} = \frac{3}{2}v$ Let the final speed of point A becomes $\frac{3}{2}v$ after turning through an angle ϕ

then $\frac{3}{2}v = \sqrt{v^2 + \omega^2R^2 + 2v\omega R\cos\phi} = \sqrt{v^2+v^2+2v^2\cos\phi} \Rightarrow \frac{3}{2} = \sqrt{2+2\cos\phi}$ or

$\Rightarrow \frac{3}{2} = \sqrt{2+2\left(2\cos^2\frac{\phi}{2}-1\right)} = 2\cos\frac{\phi}{2}\ or\ \cos\frac{\phi}{2} = \frac{3}{4} \Rightarrow \phi = 82.82^\circ$ Further if $T = \frac{2\pi R}{v}$ be the time period then by simple unitary method time taken to turn through $\phi = 82.82^\circ$ is

$t = \frac{\phi}{360} \times \frac{2\pi R}{v} = 0.036\ s$ **Ans: b**

21. At the point of closest approach (distance) the particle will have tangential velocity expressed as $v_t = \omega d = \dot{\theta} d$ By conservation of angular momentum $mvb = I\omega = md^2\,\dot{\theta} \Rightarrow \dot{\theta} = \omega = \dfrac{vb}{d^2}$

This being a case of elastic scattering, the conservation of energy provides

$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}md^2\omega^2 - \int \frac{K}{r^3}.\,dr \Rightarrow mv^2 = md^2\omega^2 + \frac{K}{d^2} \because PE = -\int \frac{K}{r^3}dr = \frac{K}{2r^2} = \frac{K}{2d^2}$$

Thereby $mv^2 = md^2\left(\dfrac{vb}{d^2}\right)^2 + \dfrac{K}{d^2} = \left(mv^2b^2 + K\right)\dfrac{1}{d^2}$ Substituting $m = 10^{-10}\,Kg$,

$v = 10^5\,ms^{-1}$ and numerically $K = b^2$ we obtain $d^2 = \left(mv^2b^2 + k\right)\dfrac{1}{mv^2} = 2b^2 \Rightarrow d = b\sqrt{2}$

Ans: b

22. According to the law of radioactive disintegration $N = N_0 e^{-\lambda t}$ The activity therefore is $-\dfrac{dN}{dt} = \lambda N_0 e^{-\lambda t}$ Given that at certain time t the activity of the sample is $\left(-\dfrac{dN}{dt}\right)_t = \dfrac{3}{5}\left(-\dfrac{dN}{dt}\right)_{t=0} = \frac{3}{5}\lambda N_0$ So $e^{-\lambda t} = \frac{3}{5} \Rightarrow \lambda t = \ln\left(\dfrac{5}{3}\right)$ or $\dfrac{\ln 2}{T} \times t = \ln\left(\dfrac{5}{3}\right)$

$\Rightarrow\ t = \dfrac{T \times \ln(5/3)}{\ln 2} = \dfrac{5570 \times 0.5108}{0.693} = 4105\,years$ **Ans: b**

23. The statement I is false but the statement II is true hence **Ans: d**

24. The statement I is true and the statement II is also true. Also the statement II is the cause of I hence **Ans: a**

25. In a swinging simple pendulum, the tension in the string at any arbitrary position may be expressed as $T = mg\cos\theta + \dfrac{mv^2}{l}$ The conservation of energy provides

$\dfrac{1}{2}mv^2 = mg\left(l\cos\theta - l\cos\theta_m\right)$ thereby $\dfrac{mv^2}{l} = 2mg\left(\cos\theta - \cos\theta_m\right)$ therefore the tension becomes $T = mg\left(3\cos\theta - 2\cos\theta_m\right)$ Obviously the tension depends on the angle θ and will be maximum when $\theta = 0$ So the maximum tension is $T_{\max} = mg\left(3 - 2\cos\theta_m\right)$ and the minimum tension (when $\theta = \theta_m$) is $T_{\min} = mg\cos\theta_m$ According to the given condition

$T_{\max} = 3T_{\min}$ Hence $mg\left(3 - 2\cos\theta_m\right) = 3mg\cos\theta_m \Rightarrow \cos\theta_m = \dfrac{3}{5} \Rightarrow \theta_m = 53.13^0$

$\Rightarrow \dfrac{\pi}{4} \le \theta_m \le \dfrac{\pi}{3}$ and the maximum tension is $T_{\max} = \dfrac{9}{5}mg$. The maximum velocity

$v_{\max}^2 = 2gl\left(1 - \cos\theta_m\right) = 2gl\left(1 - \dfrac{3}{5}\right) = \dfrac{4gl}{5} \Rightarrow v_{\max} = \sqrt{\dfrac{4gl}{5}} = 3.96\,ms^{-1}$ **Ans: a,b,c,d**

26. When the masses are released, they move in opposite direction with equal momentum i.e., $mv + MV = 0 \Rightarrow V = -\dfrac{mv}{M}$ ...(1) Numerically $V = \dfrac{mv}{M}$ Let the two masses collide for the first time after time t and the mass m turns through angle θ during this period then $t = \dfrac{\theta}{\omega_1} = \dfrac{2\pi - \theta}{\omega_2}$ or $t = \dfrac{\theta R}{v} = \dfrac{(2\pi - \theta)R}{V} \Rightarrow \left(\dfrac{1}{v} + \dfrac{1}{V}\right)\theta = \dfrac{2\pi}{V}$ Substituting the value of V, we obtain $\theta = \dfrac{2\pi M}{m+M} = \dfrac{4\pi}{3}$ if M = 2m. Also Energy conservation provide that

$$\frac{1}{2}mv^2 + \frac{1}{2}MV^2 = U_0 \quad or \quad \frac{1}{2}mv^2 + \frac{1}{2}M\left(\frac{mv}{M}\right)^2 = U_0 \text{ or } \frac{1}{2}mv^2\left[1 + \frac{m}{M}\right] = U_0$$

$\Rightarrow v = \sqrt{\dfrac{2MU_0}{m(\mathrm{m+M})}} = \sqrt{\dfrac{4U_0}{3m}}$ if M = 2m Thus the time taken for firstcollision is

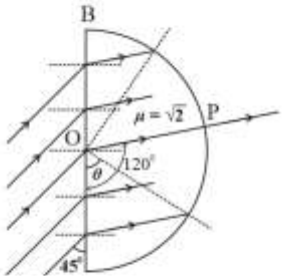
$t = \dfrac{\theta R}{v} = \dfrac{4\pi R}{3\sqrt{\dfrac{4U_0}{3m}}} = 2\pi R\sqrt{\dfrac{m}{3U_0}}$ Lastly the time taken for the second collision must be just double of it and not $2\pi R\sqrt{\dfrac{2m}{3U_0}}$ **Ans: a, b, c**

27. Given that the Electric field $\vec{E} = (3\hat{j} + b\hat{k}) \times 10^{-3} \sin[10^7(\mathrm{x} + 2\mathrm{y} + 3\mathrm{z} - \beta \mathrm{t})]$ Knowing $\vec{K}.\vec{r} = (\hat{\imath}k_x + \hat{j}k_y + \hat{k}k_z).(\hat{\imath}x + \hat{j}y + \hat{k}z) = xk_x + yk_y + zk_z$. Comparing it with the given expression we get $xk_x + yk_y + zk_z = 10^{+7}(\mathrm{x} + 2\mathrm{y} + 3\mathrm{z})$ Thereby $\Rightarrow k_x = 10^7,\ k_y = 2\times 10^7\ \&\ k_z = 3\times 10^7$ or the vector $\vec{K} = (\hat{\imath} + 2\hat{j} + 3\hat{k}) \times 10^7$

$\Rightarrow K = 10^7\sqrt{14}$ Also the speed of the wave $c = \dfrac{\beta}{K}$ $\therefore\ \beta = c \times 10^7\sqrt{14} = 3\times 10^{15}\sqrt{14}$

Furtherfor any electromagnetic wave $\vec{k}\ .\ \vec{E} = 0$ Therefore $10^{+7}(\hat{\imath} + 2\hat{j} + 3\hat{k}).(3\hat{j} + b\hat{k}) \times 10^{-3} = 0 \Rightarrow 2\times 3 + 3b = 0 \Rightarrow b = -2$ this makes option b wrong. Further the energy of an em wave is $= \dfrac{1}{2}\varepsilon_0 E^2 = \dfrac{1}{2}\varepsilon_0\left(\sqrt{3^2 + 2^2}\right)^2 \times 10^{-6} = 6.5\,\varepsilon_0\,\mu J$. The magnetic field can be obtained as $B = \dfrac{E}{c} = \dfrac{10^{-3}\sqrt{13}}{3\times 10^8} = 1.20\times 10^{-11}\,Tesla$ **Ans: a,c,d**

28. Snell's law is $\mu = \frac{\sin i}{\sin r} \Rightarrow \sqrt{2} = \frac{\sin 45}{\sin r} \Rightarrow \sin r = \frac{1}{2} \Rightarrow r = 30^0$



The critical angle is $\sin^{-1}\frac{1}{\sqrt{2}} = 45^0$.

For the emergence, theangle of incidence at curved surface must be less than 45^0 therefore angle θ should be greater than

$$\theta_{\min} = 180 - \left(90 - \sin^{-1}\left(\frac{\sin i}{\mu}\right)\right) - \sin^{-1}\left(\frac{1}{\mu}\right)$$

$$\theta_{\min} = [180 - (90 - 30) - 45] = 75^0$$

Towards the upper edge angle θ must be less than

$$\theta_{\max} = \left(90 + \sin^{-1}\left(\frac{\sin i}{\mu}\right)\right) + \sin^{-1}\left(\frac{1}{\mu}\right)$$

$$\theta_{\max} = (90 + 30) + 45 = 165$$

Thus we obtain $\theta_{\min} < \theta < \theta_{\max}$ *as* $75^0 \le \theta \le 165^0$ for the emergence of light through the curved surface.Thus the light will come out only for the angle θ lying within the range $\theta_{\max} - \theta_{\min} = 2\sin^{-1}\left(\frac{1}{\mu}\right)$ which is independent of the angle of incidence but depends on the refractive index (μ) of the material. Of course the range is same for all values of angle of incidence yet the values of $\theta_{\min}$ *and* $\theta_{\max}$ are different for different values of angle of incidence. Hence option **b is not correct**. The light coming out of the curved surface will go away from normal hence towards the line which is the increased radius for $\theta = 120^0$ and thus form a convergent beam towards the enhanced radius corresponding to $\theta = 120^0$.

Ans: a, c, d

29. The rate of flow of heat in a solid rod is expressed as the thermal current

$H = \frac{dQ}{dt} = KA\left(-\frac{dT}{dx}\right)$ Given that the thermal conductivity $K = \frac{\alpha}{T}$ so one can write

$H\int_0^l dx = -\alpha A\int_{90}^{10}\frac{dT}{T} \Rightarrow Hl = -\alpha A \ln\frac{10}{90} = 2\alpha A \ln 3$ using $l = 2m$ we get

$H = \alpha A \ln 3 = 1.1\alpha A$ Further at any intermediate location at a distance x from hot end

$$H\int_0^x dx = -\alpha A\int_{90}^{T}\frac{dT}{T} \Rightarrow Hx = -\alpha A \ln\frac{T}{90} \Rightarrow T = 90 \times e^{-Hx/\alpha A}$$

$At\ x = 0.5\ m,\ T = 90 \times e^{-Hx/\alpha A} = 90e^{-1.1 \times 0.5} = 51.96^0\ C$ Also

$At\ x = 1.5m,\ T = 90e^{-1.1 \times 1.5} = 17.32^0 C$ The temperature gradient may be expressed as $\frac{dT}{dx} = -\frac{TH}{\alpha A}$ is higher near the hotter end than that near the colder end.

Ans: a, b, c, d

30. According to Bohr theory, in an hydrogen atom an electron revolves round the proton, the centripetal force being provided by electrostatic attraction. Such that

$$\frac{mv^2}{r}=\frac{1}{4\pi\varepsilon_0}\frac{e.e}{r^2} \quad \text{or}\; mv^2r=Ke^2---(1)$$

where $v\,and\,r$ are the velocity of electron and the radius of the orbit and $K=\frac{1}{4\pi\varepsilon_0}$

According to Bohr quantum condition (second postulate)

$$mvr=n\frac{h}{2\pi}\;\; or\;\; mvr=n\hbar---(2)$$

Dividing eq (1) by eq (2) $v=\frac{Ke^2}{n\hbar}\Longrightarrow$ v does not depend on mass. Now substituting v in equation (2)

$$m\left(\frac{Ke^2}{n\hbar}\right)r=n\hbar\Rightarrow r=\frac{n^2\hbar^2}{Kme^2}\text{ showing that } r\propto\frac{1}{m}$$

The total energy E = KE + PE

$$=\frac{1}{2}mv^2-\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}=\frac{1}{2}m\left(\frac{Ke^2}{n\hbar}\right)^2-\frac{Ke^2}{r}$$

$$E=\frac{1}{2}\frac{mK^2e^4}{n^2\hbar^2}-\frac{Ke^2}{n^2\hbar^2}Kme^2\;\; E_n=-\frac{1}{2}\frac{mK^2e^4}{n^2\hbar^2}\Rightarrow E\propto m$$

To understand the situation more specifically, one replaces the mass of electron by the effective mass i.e. the reduced mass (μ) which for the case of hydrogen atom is

$\mu=\frac{m\times1836m}{m+1836m}\approx m(\text{electron mass})$ Thus for hydrogen atom the

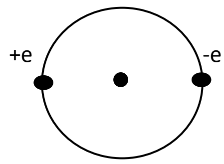
Radius of first orbit $r=a_0=\frac{\hbar^2}{Kme^2}$ we have substituted n = 1

Velocity of electron in first orbit $v=v_0=\frac{Ke^2}{\hbar}$

Energy of electron in first orbit E= $E_0=-\frac{1}{2}\frac{mK^2e^4}{\hbar^2}\Rightarrow E\propto m$

A positronium is a short lived atomic entity in which a negatively charged electron is said to revolve round a positron (a positive particle having charge and mass equal to an electron even sometimes known as a positive electron) Since the particles have equal mass, the rotation takes place around the centre of mass which lies midway between the two.

In case of positronium the reduced mass is $\mu=\frac{mm}{m+m}=\frac{m}{2}$



Thereby the radius becomes $r=a=\frac{\hbar^2}{K(m/2)e^2}=\frac{2\hbar^2}{Kme^2}=2a_0$

And energy becomes $E=-\frac{1}{2}\frac{(m/2)K^2e^4}{n^2\hbar^2}\Rightarrow E=-\frac{1}{4}\frac{mK^2e^4}{n^2\hbar^2}=\frac{E_0}{2}$ **Ans: a, c**

31. The focal length f_2 of a lens of refractive index μ and radii of curvature R_1 and R_2 when the refractive index of the object space is μ_1 and that of image space is μ_2 is calculated by

$\frac{\mu_2}{f_2} = \frac{\mu-\mu_1}{R_1} - \frac{\mu-\mu_2}{R_2}$ If the lens is kept in air $\mu_1 = 1$ and $\mu_2 = 1$ then

$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5-1)\left(\frac{1}{20} - \frac{1}{-60}\right) = \frac{1}{30} \Rightarrow f = 30\,cm$ Hence a is correct.

When the lens is silvered on the surface of radius 60 cm, it will behave as a concave mirror of focal length f_M such that

$\frac{1}{f_M} = \sum \frac{1}{f} = \frac{1}{f_{lens}} + \frac{2}{R} + \frac{1}{f_{lens}} = \frac{1}{30} + \frac{2}{60} + \frac{1}{30} = \frac{6}{60} = \frac{1}{10}$ *means* $f_M = 10\,cm$

Hence the option b is correct.

When the image space is filled with a liquid of refractive index $\mu_2 = \frac{5}{3}$, the object space still being air ($\mu_1 = 1$), the second focal length of the lens is obtained by $\frac{5}{3f_2} = \frac{1.5-1}{+20} - \frac{1.5 - \frac{5}{3}}{-60}$

$\Rightarrow f_2 = +\,75\,cm$ Also the first focal length in this case is $f_1 = +\,45\,cm$ so the lens still behaves as convex lens and not a concave (diverging) lens. Hence option c is wrong.

Considering a different situation when air in object space and water $\left(\mu = \frac{4}{3}\right)$ in image space, the second focal length of lens then is $\frac{4}{3f_2} = \frac{1.5-1}{20} - \frac{1.5 - 4/3}{-60} = \frac{1}{36} \Rightarrow f_2 = +\,48\,cm$

Hence a beam of light incident parallel to the principal axis focuses 48 cm behind the lens. Hence option d is correct. **Ans: a, b, d**

32. A poorly conducting thick hollow cylinder is placed coaxially inside a long solenoid. If we consider a circle of radius r (a < r < b), the magnetic flux through this area shall be $\phi = \pi r^2 \beta t$

The induced emf therefore shall be $\varepsilon = -\frac{d\phi}{dt} = -\,\pi r^2 \beta$ Thus $|\varepsilon| = \pi r^2 \beta$ If R be the resistance offered to the circulating current then $\frac{1}{R} = \int_a^b \frac{hdr}{\rho \times 2\pi r} = \frac{h}{2\pi\rho} \ln\frac{b}{a}$ Thereby

$R = \frac{2\pi\rho}{h \times \ln\frac{b}{a}}$ Further the circulating current induced in the thick hollow poorly conducting cylinder is $i = \frac{\varepsilon}{R} = \int_a^b \pi r^2 \beta \frac{hdr}{\rho 2\pi r} = \frac{\beta h}{2\rho}\int_a^b r dr = \frac{\beta h}{4\rho}\left(b^2 - a^2\right)$

The time varying magnetic field parallel to the axis of the solenoid produces an electric field even outside the solenoid. The lines of force being circular with their centres lying on the axis of the solenoid so option d is wrong. **Ans: a, b, c**

INTERNATIONAL OLYMPIAD QUALIFIER IN PHYSICS 2020-21
Paper code 61 Solutions: (1.3.2021)

1. Let time t depend on c, h and G such that
$t = c^x h^y G^z$ Taking dimensions on both sides
$M^0 L^0 T^1 = \left(LT^{-1}\right)^x \left(ML^2T^{-1}\right)^y \left(M^{-1}L^3T^{-2}\right)^z$
or $M^0 L^0 T^1 = L^{x+2y+3z} M^{y-z} T^{-x-y-2z}$
Giving $y - z = 0$ (1) $x + 2y + 3z = 0$ (2) $-x - y - 2z = 0$ (3)
Or $y = z$ Putting in (2) we get $x = -5y$ then from (3) $5y - y - 2y = 1$
$\Rightarrow 2y = 1 \Rightarrow y = \frac{1}{2}$, $x = -\frac{5}{2}$ and $z = \frac{1}{2}$ So we get $t = c^{-\frac{5}{2}} h^{\frac{1}{2}} G^{\frac{1}{2}} \Rightarrow \sqrt{\frac{hG}{c^5}}$

Ans: d

2. The mass of the composite system is $M = \frac{2}{3}\pi R^3 \rho + \pi R^2 \ell \rho = \frac{2}{3}\pi R^3 \rho \left(1 + \frac{3\ell}{2R}\right)$

The moment of Inertia is $I = \frac{2}{5} \times \frac{2}{3}\pi R^3 \rho R^2 + \frac{1}{2}\pi R^2 \ell \rho R^2 = \frac{4}{15}\pi R^5 \rho \left(1 + \frac{15\ell}{8R}\right)$ using now

I=MK^2 we get $K = \sqrt{\dfrac{\frac{4}{15}\pi R^5 \rho \left(1 + \frac{15\ell}{8R}\right)}{\frac{2}{3}\pi R^3 \rho \left(1 + \frac{3\ell}{2R}\right)}} = R\sqrt{\frac{1}{10}\frac{(8R + 15\ell)}{(2R + 3\ell)}}$

Ans: b

3. $g' = g - \omega^2 R$ where g' is apparent acceleration due to gravity and $\omega = \frac{2\pi}{T}$ is the angular velocity at the verge of fly off means $g' = 0$ or $g = \omega^2 R = \left(\frac{2\pi}{T}\right)^2 R$ Thereby

$\frac{G}{R^2}\frac{4}{3}\pi R^3 \rho = \left(\frac{2\pi}{T}\right)^2 R \Rightarrow T = \sqrt{\frac{3\pi}{\rho G}}$

Ans: c

4. Let the stationary mass m explodes in to m_1 and m_2
By conservation of momentum $m_1 v_1 + m_2 v_2 = 0$ (1) and Energy is
$\frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 = 1680 \Rightarrow \frac{1}{2}m_1 v_1^2 \left(1 + \frac{m_1}{m_2}\right) = 1680$
$\Rightarrow v_1 = 12\ ms^{-1}$ and $\Rightarrow v_2 = -28\ ms^{-1}$ Thereby $v_1 - v_2 = \left[12 - (-28)\right] ms^{-1} = 40\ ms^{-1}$
Thus we get $v_{rel} = 40\ ms^{-1}$
Ans: a

5. For a projectile the maximum height is $H = \dfrac{u^2 \sin^2 \alpha}{2g}$ and the range is $R = \dfrac{u^2 \sin 2\alpha}{g}$

For the given problem $\dfrac{H}{R/2} = \tan\beta \Rightarrow \dfrac{\sin^2 \alpha}{\sin 2\alpha} = \tan\beta \Rightarrow \tan\alpha = 2\tan\beta$

Ans: a

6. As particle starts from rest, it must have started from extreme position. So equation of SHM is $x = A\cos\omega t$, where A is amplitude and x displacement from Centre.

Given that at $t = 1,\ x = A - a \ \Rightarrow A - a = A\cos(\omega \times 1)$.............(1) and

at $t = 2,\ \ x = A - a - b \Rightarrow A - a - b = A\cos(\omega \times 2)$................(2)

Using $\cos 2\omega = 2cos^2\omega - 1$ one obtains $A = \dfrac{2a^2}{3a - b}$

Ans: a

7. The velocity is changing on circular path so centripital acceleration and tangential acceleration both Further Given is that $\frac{1}{2}mv^2 = as^2 \Rightarrow \dfrac{mv^2}{R} = \dfrac{2as^2}{R}$ centripetal force

Also $mv^2 = 2as^2 \Rightarrow v = \sqrt{\dfrac{2a}{m}}\ s \Rightarrow \dfrac{dv}{dt} = \sqrt{\dfrac{2a}{m}}\ \dfrac{ds}{dt} = \sqrt{\dfrac{2a}{m}}\sqrt{\dfrac{2a}{m}}\ s$

$\Rightarrow \dfrac{dv}{dt} = \dfrac{2a}{m} s \Rightarrow m\dfrac{dv}{dt} = 2as =$ tangential force

Net force as a function of s is $F = \sqrt{F_T^2 + F_R^2} \Rightarrow 2as\sqrt{1 + \left(\dfrac{s}{R}\right)^2}$

Ans: d

8. From eq. of continuity $A_1v_1 = A_2\,v_2$. ------(1)

Given that $A_1 = 10\ cm^2$ and $A_2 = 5\ cm^2$ and $v_1 = 1$ m/sPutting in (1) gives $v_2 = 2$m/s

For horizontal tube from Bernoulli eq.

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$.-----------(2)

Now put in eq (2)P_1= 2000 Pa, $\rho = 10^3$ kg/m^3. Also $v_1 = 1$ m/s and $v_2 = 2$m/s

And get $P_2 = 500$ Pa.

Ans: d

9. Let $\theta_1, \theta_2\ and\ \theta_3$ be the temperature of water in the three containers.

When one litre from A and two litre from B is mixed, we get

$(\theta_1 - 52) = 2(52 - \theta_2) \Rightarrow \theta_1 + 2\theta_2 = 3 \times 52$

When one litre from B and two litre from C is mixed, we get

$(\theta_2 - 40) = 2(40 - \theta_3) \Rightarrow \theta_2 + 2\theta_3 = 3 \times 40$

When one litre from C and two litre from A is mixed, we get

$(\theta_3 - 34) = 2(34 - \theta_1) \Rightarrow \theta_3 + 2\theta_1 = 3\times 34$

Adding the three, we get $3(\theta_1+\theta_2+\theta_3) = 3\times(52+40+34) \Rightarrow \theta_1+\theta_2+\theta_3 = 126$ If θ_0 is the temperature when one litre from each A, B and C is mixed then

$(\theta_1-\theta_0) = (\theta_0-\theta_2)+(\theta_0-\theta_3) \Rightarrow \theta_1+\theta_2+\theta_3 = 3\theta_0 \Rightarrow \theta_0 = 42^\circ$

Ans: b

10. The force along x axis is

$$F_x = \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{\ell^2} + 2\frac{q^2}{\left(\ell\sqrt{2}\right)^2}\frac{1}{\sqrt{2}} + \frac{q^2}{\left(\ell\sqrt{3}\right)^2}\frac{1}{\sqrt{3}}\right] = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{\ell^2}\left[1+\frac{1}{\sqrt{2}}+\frac{1}{3\sqrt{3}}\right]$$ Similar

expressions are held along y and z axes. Hence the resultant force is

$$F = \sqrt{F_x^2+F_y^2+F_z^2} \Rightarrow$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{\ell^2}\left[1+\frac{1}{\sqrt{2}}+\frac{1}{3\sqrt{3}}\right]\sqrt{\{1+1+1\}} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{\ell^2}\left[\sqrt{3}+\sqrt{\frac{3}{2}}+\frac{1}{3}\right] = \frac{0.8225\, q^2}{\pi\varepsilon_0\ell^2}$$

Or $F = \dfrac{(1-0.1775)\, q^2}{\pi\varepsilon_0\ell^2}$

Ans: c

11. The internal resistance 'r' of a cell is measured by a potentiometer as

$r = \left(\frac{L}{L_1}-1\right)R_1 = \left(\frac{L}{L_2}-1\right)R_2$ **where** L is the balancing length when cell is in open circuit and L_1 when the cell is shunted by resistance R_1 and L_2 when cell is shunted by resistance R_2. Given that$L$=250cm, R_1= 7.5 Ω, L_1= 250 – 25 = 225cm, R_2= 20Ω, This gives L_2= 240 cm

Ans: a

12. Knowing that $C_V = \dfrac{R}{(\gamma-1)}$, $C_P = \dfrac{\gamma R}{(\gamma-1)}$ *and* $\gamma_{mix} = \dfrac{n_1C_{P1}+n_2C_{P2}}{n_1C_{V1}+n_2C_{V2}}$ with

$\gamma_1 = \frac{5}{3}$ *and* $\gamma_2 = \frac{7}{5}$ *and* $n_1 = 1$, & $n_2 = 2$, we get

$C_{V1} = \frac{3}{2}R$, $C_{P1} = \frac{5}{2}R$ *and* $C_{V2} = \frac{5}{2}R$, $C_{P2} = \frac{7}{2}R$ and obtain

$$\gamma_{mix} = \frac{n_1C_{P1}+n_2C_{P2}}{n_1C_{V1}+n_2C_{V2}} = \frac{19}{13} = 1.46$$

Ans: b

13. Given that $PT^3 = K$, using $PV = \mu RT$ or $P = \dfrac{\mu RT}{V}$ we get

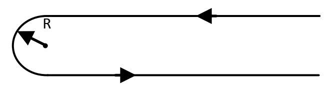
$$\frac{\mu RT}{V}T^3 = K \;\; or \;\; T^4 = \frac{KV}{\mu R} \quad \text{differentiating we get } 4T^3\,dT = \frac{KdV}{\mu R} \text{ Thereby}$$

$$\frac{dV}{dT} = \frac{4\mu RT.T^2}{K} = \frac{4V}{T}\; so\ coefficient\ of\ volume \text{ expension } \frac{1}{V}\frac{dV}{dT} = \frac{4}{T}$$

Ans: d

14. Magnetic field at the centre of arc O is due to semi-circular part and to two semi infinite straight lines.

So $B = \dfrac{\mu_0 I}{4R} + 2\left[\dfrac{\mu_0}{4\pi}\dfrac{I}{R}\left(\sin 0 + \sin 90\right)\right] = \dfrac{\mu_0 I}{4R}\left(1 + \dfrac{2}{\pi}\right)$



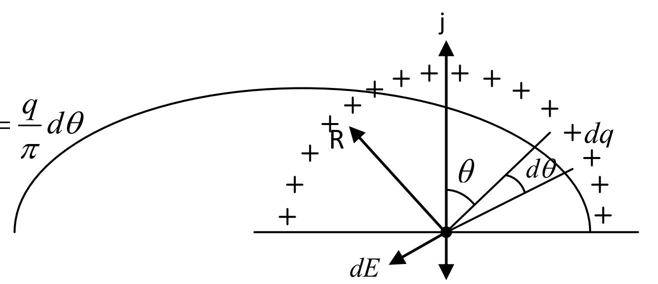
$B = \dfrac{\mu_0}{4\pi}\dfrac{I}{R}\left(\pi + 2\right)$

Ans: a

15. By symmetry net electric field along X-axis at the centre O is zero and the electric field along y axis will be added up

$$dE_y = \left(-\hat{j}\right)\frac{1}{4\pi\varepsilon_0}\frac{dq}{R^2}\cos\theta$$

$$where\ \ \mathrm{dq} = \lambda\left(Rd\theta\right) = \frac{q}{\pi R}\left(Rd\theta\right) = \frac{q}{\pi}d\theta$$



$$E_y = \left(-\hat{j}\right)2\times\frac{1}{4\pi\varepsilon_0}\int_0^{\frac{\pi}{2}}\frac{\left(\dfrac{q}{\pi}\cos\theta d\theta\right)}{R^2}$$

$$E_y = \left(-\hat{j}\right)\frac{q}{2\pi^2\varepsilon_0 R^2}$$

Ans: a

16. The current is $i = \mathrm{i}_1 \cos\omega t + i_2\ sin\,\omega t = \mathrm{i}_1\left(\cos\omega t + \dfrac{i_2}{\mathrm{i}_1}\ sin\,\omega t\right)$ let us put

$$\frac{i_2}{i_1} = \cot\theta = \frac{\cos\theta}{\sin\theta} \text{ then } \mathrm{i} = \frac{\mathrm{i}_1}{\sin\theta}\left(\cos\omega t\sin\theta + \ sin\,\omega t\cos\theta\right) \text{or}$$

$$\mathrm{i} = \frac{\mathrm{i}_1}{\dfrac{i_1}{\sqrt{i_1^2 + i_2^2}}}\sin\left(\omega t + \theta\right) \text{or } \mathrm{i} = \sqrt{\left(i_1^2 + i_2^2\right)}\sin\left(\omega t + \theta\right) \text{ Thereby rms current is}$$

$$\mathrm{i}_{rms} = \sqrt{\frac{\left(i_1^2 + i_2^2\right)}{2}}$$

Ans: c

17. The potential at the origin may be expressed as

$$V_0 = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{x_0} - \frac{q}{2x_0} + \frac{q}{3x_0} - \frac{q}{4x_0} + \frac{q}{5x_0}............\right)$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{x_0}\left(1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \frac{1}{6} + ...\right)$$ using now

$$\log_e(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} + \frac{x^4}{4} + \frac{x^5}{5} - \frac{x^6}{6}......... \quad for\ -1 < x \le 1$$

$$\ln 2 = 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \frac{1}{6}........$$

One obtains $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{x_0}\ln 2$

Ans: b

18. The mass defect $\Delta m =$(mass of ${}^{23}_{10}Ne$ - mass of 10 electrons) - (mass of ${}^{23}_{11}Na$ - mass of 11 electrons) – mass of one electron

Or $\Delta m =$(mass of ${}^{23}_{10}Ne$) - (mass of ${}^{23}_{11}Na$) = (22.994466) - (22.989770)=0.004696 amu

Thereby $\Delta E = 0.004696 \times 931.5 = 4.374\ MeV$ This energy is shared between the electron and the neutrino. In an extreeme situation the electron can take the wholeof this energy so the maximum energy the electron can have is 4.374 MeV

Ans:a

19. The resultant intensity on the screen is given by $I = I_m \cos^2\left(\frac{\pi}{\lambda} d \frac{y}{D}\right) = \frac{1}{4} I_m$

Thereby $\cos^2\left(\frac{\pi}{\lambda} d \frac{y}{D}\right) = \frac{1}{4} \Rightarrow \frac{\pi}{\lambda} d \frac{y}{D} = \frac{\pi}{3} \Rightarrow y = \frac{D\lambda}{3d}$

$$y = \frac{1.20 \times 600 \times 10^{-9}}{3 \times 2.5 \times 10^{-3}} = 96 \times 10^{-6} m = 96 \mu m$$

Ans: c

20. Let the initial current through the coil be I_0 at $t = 0$. The current decrease down to zero halving after each Δt second This means that the current at any time t is expressed as $i = I_0 e^{-\frac{\ln 2}{\Delta t}t}$. The heat produced in time dt in the coil is $dH = i^2 R dt$. The total heat produced will be $H = \int_0^{\infty} i^2 R dt$ Substituting the values $H = \int_0^{\infty} I_0^2 e^{-2\frac{\ln 2}{\Delta t}t} R dt = I_0^2 R \int_0^{\infty} e^{-2\frac{\ln 2}{\Delta t}t} dt = \frac{I_0^2 R \Delta t}{-2\ln 2}\left\{ e^{-2\frac{\ln 2}{\Delta t}t}\Big|_0^{\infty} \right\} = \frac{I_0^2 R \Delta t}{2\ln 2}$ ....(1) Also we know

$i = \frac{dQ}{dt}$ or $dQ = idt$ or $Q = \int_0^q dQ = \int_0^\infty idt = \int^\infty I_0 e^{-\frac{\ln 2}{\Delta t}t} dt = \left\{ -\frac{I_0 \Delta t}{\ln 2} e^{-\frac{\ln 2}{\Delta t}t} \Big|_0^\infty \right\} = \frac{I_0 \Delta t}{\ln 2}$ or

$I_0 = \frac{Q \ln 2}{\Delta t}$ Substituting in (1) $H = \frac{\left(\frac{Q \ln 2}{\Delta t}\right)^2 R \Delta t}{2 \ln 2} = \frac{1}{2} \frac{Q^2 R}{\Delta t} \ln 2$ Ans

Ans: c

21. When switch S is closed, current starts flowing and is given by

$I = I_0(1 - e^{\frac{-t}{\tau}}) \quad = \frac{E}{R}\left(1 - e^{\frac{-t}{\tau}}\right) = \frac{dq}{dt}$ Therefore $q = \int_0^\tau I\, dt \; = \; q = \frac{E}{R}\int_0^\tau \left(1 - e^{\frac{-t}{\tau}}\right) dt$

Where charge q flows in time τ ($\because \tau = \frac{L}{R}$ = time constant)

$$q = \frac{E}{R}\tau - \frac{E}{R}\int_0^\tau e^{\frac{-t}{\tau}} dt = \frac{E}{R}\tau - \frac{E}{R}\left[\frac{e^{\frac{-t}{\tau}}}{\left(\frac{-1}{\tau}\right)}\right]_0^\tau \quad = \frac{E}{R}\tau + \frac{E}{R}\tau\left[e^{\frac{-t}{\tau}}\right]_0^\tau$$

$$q = \frac{E}{R}\tau + \left(\frac{E}{R}\tau e^{-1} - \frac{E}{R}\tau e^0\right) = \frac{E\tau}{eR} = \frac{E\left(\frac{L}{R}\right)}{eR} = \frac{EL}{eR^2}$$

Ans: a

22. In a sample of uranium of mass M, the masses of the two isotopes are

$M_1 = \frac{140}{141}M$ *and* $M_2 = \frac{1}{141}M$ The number of atoms of the two isotopes are

$N_1 = \frac{140}{141}M\frac{N_A}{238}$ *and* $N_2 = \frac{1}{141}M\frac{N_A}{235}$ Knowing further that $N = N_0 e^{-\lambda t}$ gives the Activity as $A_1 = -\frac{dN_1}{dt} = \lambda N_1 = \frac{\ln 2}{T_1}\frac{140}{141}M\frac{N_A}{238}$ and $A_2 = -\frac{dN_2}{dt} = \lambda N_2 = \frac{\ln 2}{T_2}\frac{1}{141}M\frac{N_A}{235}$ The relative contribution of Activity thus turns out to be $\frac{A_1}{A_1 + A_2} : \frac{A_2}{A_1 + A_2} \Rightarrow$

$$\frac{1}{4.5}\times\frac{140}{238} : \frac{1}{0.7}\times\frac{1}{235}$$

$$\Rightarrow 0.1307 : 0.0060 :: \frac{0.1307}{0.1367}\times 100 : \frac{0.0061}{0,1367}\times 100 \Rightarrow 95.6\% \textit{ and } 4.4\%$$

Ans: c

23. The focal length of a lens is obtained by $\frac{\mu_2}{f_2} = \frac{\mu - \mu_1}{R_1} - \frac{\mu - \mu_2}{R_2}$ …..(1) where μ, μ_1 & μ_2 are the refractive indices of the material of lens, the object space and the image space respectively. R_1 & R_2 are the two radii of the lens. f_2 is the second focal length. When the lens is placed in air $\mu = 1.5, \mu_1 = 1$ & $\mu_2 = 1$ and then $\frac{1}{25} = \frac{1}{f} = \frac{1.5-1}{R} - \frac{1.5-1}{-R} \Rightarrow R = 25$

In the present case $\mu = 1.5, \mu_1 = 1$ & $\mu_2 = \frac{4}{3}$ Then equation (1) yields $\frac{4}{3f_2} = \frac{\frac{3}{2}-1}{25} - \frac{\frac{3}{2}-\frac{4}{3}}{-25}$

$\Rightarrow f_2 = 50\ cm$ Hence the sun will be focused 50 below the lens.

Ans: c

24.Lymen series of hydrogen spectrum falls in ultra violet region. Minimum energy photon of Lymen series is emitted for transition from n=2 to n=1 and has an energy $13.6\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ eV = 10.2 eV. All other spectral lines will be of higher energies and so the frequencies. Therefore if this 10.2 eV photon can eject photo electron then other will definitely. So required threshold frequency ν is

$$\nu = \frac{10.2 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}\ Hz = 2.46 \times 10^{15}\ Hz$$

Ans : c

Multiple choice questions (Any number of options may be correct)

25. When battery has been disconnected, the charge Q remains unchanged

$$Q = C_{air}V = \left(\frac{\varepsilon_0 A}{d}\right)V = k\varepsilon_0 AE$$

Electric field in dielectric between plates of capacitor $E = \frac{\sigma}{K\varepsilon_0} = \frac{E_{air}}{K} = \frac{V}{Kd}$

Work done on the system = $\frac{Q^2}{2C_{air}} - \frac{Q^2}{2C_{dielectric}} = \frac{Q^2}{2}\left[\frac{1}{C_{air}} - \frac{1}{C_{dielectric}}\right]$

W = $\frac{1}{2}\left(\frac{\varepsilon_0 AV}{d}\right)^2\left(\frac{d}{\varepsilon_0 A} - \frac{d}{k\varepsilon_0 A}\right) = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{k}\right]$

Ans: a, & c

26. The gravitational field due to a uniform solid sphere of mass M and radius R at a distance r from its centre is

$F(r) = \left(\frac{GM}{R^3}\right)r \quad if\ r < R$ and $F(R) = \frac{GM}{r^2} \quad if\ r > R$ Thereby

$\frac{F(r_1)}{F(r_2)} = \frac{r_1}{r_2}\ for\ r_1 \le R\ and\ r_2 \le R$ and $\frac{F(r_1)}{F(r_2)} = \frac{r_2^2}{r_1^2}\ for\ r_1 \ge R\ and\ r_2 \ge R$

Ans: a & b

27.The resultant intensity is $I_0 = I + I + 2\sqrt{I \times I}\cos 0 = 4I$ when the intensity of one source is reduced by 64 % it becomes $I - 0.64I = 0.36I$ Then the resultant intensity becomes $I_{\mathrm{Re}sult} = 0.36I + I + 2\sqrt{0.36I \times I}\cos\phi = I_0\left(0.34 + 0.30\cos\phi\right)$ where phase ϕ is now varied.

When $\phi = 0$, The intensity at P is $I_{\mathrm{Re}sult} = 0.64I_0 = I_{\max}$ Ans a

When $\phi = \frac{\pi}{2}$. The intensity at P is $I_{\mathrm{Re}sult} = 0.34I_0$

When $\phi = \pi$ The intensity at P is $I_{\mathrm{Re}sult} = 0.04I_0 = I_{\min}$

This shows that $\frac{I_{\max}}{I_{\min}} = \frac{0.64}{0.04} = 16$ Ans c

Ans: a & c

28. The given parameters are $P_i = 1\times10^5\ \mathrm{N/m^2}$, $V_i = 2\times10^{-3}\ \mathrm{m^3}$,

$P_f = P_o + \frac{kx}{A} = 1.5\times10^5 N/m^2$ and $V_f = V_0 + Ax = 2.4\times10^{-3}m^3$ Now $T_f = \frac{P_F \times V_f}{P_i V_i}T_i = 720K$

And $\Delta U = nC_V dT = \frac{nR}{\gamma - 1}dT = \frac{P_i V_i}{\gamma - 1}\frac{dT}{T} = 240J$ $\Delta W = P_0 Ax + \frac{1}{2}kx^2 = 50J$ Then $\Delta Q = \Delta U + \Delta W = 290J$

Ans: a, b & d

29. Given that $U_x = U_0(1 - \cos ax)$ The force $F = -\frac{dU_x}{dx} = -aU_0 \sin \mathrm{ax}$ For small displacement x it turns out to $F = -\frac{dU_x}{dx} = -a^2U_0\,\mathrm{x}$ Obviously the force is zero at x = 0showing that x = o is the equilibrium position. The equilibrium is stable as the second derivative of potential function is negative. Once again $m\frac{d^2x}{dt^2} = -a^2U_0\,\mathrm{x}$ is the equation of SHM whose time period is $T = 2\pi\sqrt{\frac{m}{a^2U_0}}$ and its angular frequency is $\omega = \sqrt{\frac{a^2U_0}{m}} = a\sqrt{\frac{U_0}{m}}$

Ans: a, b, c & d

30. The refractive index of the prismis $\mu = 1.6 = \frac{\sin\left(\frac{A + \partial_m}{2}\right)}{\sin\frac{A}{2}}$ where ∂_m is the angle of minimum deviation. Using $\mu = 1.6$ and $A = 60^0$ One gets,

$\sin\frac{A+\partial_m}{2}=0.8 \Rightarrow \frac{A+\partial_m}{2}=53^\circ \Rightarrow \partial_m=46^\circ$ **Ansb**Also the angle of incidence here is

$i=\left(\frac{A+\partial_m}{2}\right)=\frac{60+46}{2}=53^\circ$ Ans a

Nowthe prism is immersed in water of refractive index ${}_a\mu_w=\frac{4}{3}$, the angle of minimum deviation may now be obtained from ${}_w\mu_g=\frac{{}_a\mu_g}{{}_a\mu_w}=\frac{1.6}{4/3}=1.2=\frac{\sin\left(\frac{A+\partial_m}{2}\right)}{\sin\frac{A}{2}} \Rightarrow \left(\frac{A+\partial_m}{2}\right)=37^\circ \Rightarrow \partial_m=14^\circ$ A

When immersed in a liquid of refractive index ${}_a\mu_l=1.2$, The deviation may be obtained from ${}_l\mu_g\sin\frac{A}{2}=\sin\left(\frac{A+\partial_m}{2}\right)$ or $\frac{1.6}{1.2}\sin\frac{60}{2}=\sin\left(\frac{60+\partial_m}{2}\right) \Rightarrow \partial_m=23.6^\circ$

Ans: a, b, c & d

31.The current in a p – n junction diode is expressed as

$i=i_0\left(e^{eV/kT}-1\right)$ At 300 K, the value of $\frac{qV}{kT}=\frac{1.6\times10^{-19}\times0.6}{1.38\times10^{-23}\times300}=23.2$ Therefore the current $i=5\times10^{-12}\left(e^{23.2}-1\right)=5.0\times10^{-12}\times1.190\times10^{10}\ or\ \ i=0.0595A\cong 59.5\ mA$ Now when $V=0.7$ V The value of $\frac{qV}{kT}=\frac{1.6\times10^{-19}\times0.7}{1.38\times10^{-23}\times300}=27.053$ and the current $i=i_0\left(e^{27.053}-1\right)$

$i=5.0\times10^{-12}\times5.610\times10^{11} \Rightarrow i=2.805A$

Thereby the change in current when voltage is changed from 0.6 V to 0.7 V is

$\Delta i=2.805-\ 0.0595A\cong 2.75\ A$

For dynamic resistance, using now $i=i_0\left(e^{qV/kT}-1\right)$ we get $\left.\frac{di}{dV}\right|_T=\frac{qi_0}{kT}\left(e^{qV/kT}\right)$.

At V = 0.6 volt, $\left.\frac{di}{dV}\right|_{T=300K}=\frac{qi_0}{kT}\left(e^{23.2}\right)=\frac{1.6\times5}{1.38\times3}10^{-10}\times1.19\times10^{10}\cong 2.3\mho$

Therefore the dynamic resistance of the diode at a biasing voltage of 0.6 volt is

$R_d=\left.\frac{dV}{di}\right|_{V=0.6V,T=300K}=\frac{1}{2.3}=0.435\!=435\ m\Omega$

In the reverse bias the current practically remains constant up to a large value known as break down voltage so no change in reverse bias current occurs when voltage changes from -1V to -2V

Ans: a, b, c & d

average

32.In the absence of electric field, when the drop falls under gravity alone, its speed is $v = \frac{distance\ covered}{time} \Rightarrow v = \frac{2.0\times10^{-3} m}{35.7 s} = 0.056\ \frac{mm}{s}$ Also the next

$v = \frac{1.2\times10^{-3} m}{21,4 s} = 0.056\ \frac{mm}{s}$ This shows that this is the terminal velocity.

Therefore the apparent weight of the drop of radius r and density ρ equals the viscous force, that is, $\frac{4}{3}\pi r^3(\rho-\sigma)g = 6\pi\eta r v$ Where σ is the density and η the viscosity of air.

Thus, $r = \sqrt{\frac{9\eta v}{2(\rho-\sigma)g}}$ or $r = \sqrt{\frac{9\times(1.80\times10^{-5})\times(0.056\times10^{-3})}{2\times(880-1.29)\times9.81}} \Rightarrow r = 7.26\times10^{-7} m$

When the drop is held stationary in the electric field, the upward electric force on the drop equals the apparent weight of the drop. That is,

$qE = \frac{4}{3}\pi r^3(\rho-\sigma)g$ or $q = \frac{4\pi r^3(\rho-\sigma)g}{3E}$ Here $E = \frac{V}{d} = \frac{103}{6.0\times10^{-3}}\ Vm^{-1}$

$$\therefore\ q = \frac{4\times3.14\times(7.26\times10^{-7})^3\times(880-1.29)\times9.81}{3\times103/6.0\times10^{-3}}$$

$or\ \ q = \frac{4\times3.14\times(7.26)^3\times878.71\times9.81\times6.0}{3\times103}\times10^{-24} = 8.045\times10^{-19} C$ to achieve equilibrium this chage must be negative

Now q = ne, where n is the number of excess electrons on the drop. Therefore,

$n = \frac{q}{e} = \frac{8.045\times10^{-19}}{1.6\times10^{-19}} = 5$ Thus the drop carries 5 excess electrons.

Ans: a,c &d

Indian Olympiad Qualifier in Physics (IOQP) 2021-2022

conducted jointly by

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

and

Indian Association of Physics Teachers (IAPT)

Part II: Indian National Physics Olympiad (INPhO)

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

Date: 13 March 2022

Time: **10:30-12:30 (2 hours)** Maximum Marks: **50**

Instructions **Roll No.:**

1. This booklet consists of 4 pages and total of 5 questions. Write roll number at the top wherever asked.

2. Booklet to write the answers is provided separately. Instructions to write the answers are on the Answer Booklet.

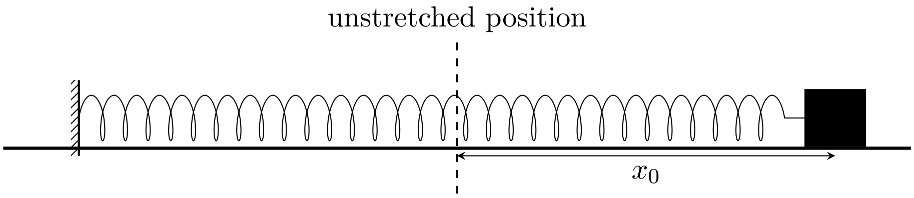
3. Marks will be awarded on the basis of what you write on both the Summary Answer Sheet and the Detailed Answer Sheets in the Answer Booklet. Simple short answers and plots may be directly entered in the Summary Answer Sheet. Marks may be deducted for absence of detailed work in questions involving longer calculations.

4. Strike out any rough work that you do not want to be considered for evaluation. You may also use the space on the Question Paper for rough work – this will NOT be evaluated.

5. Non-programmable scientific calculators are allowed. Mobile phones **cannot** be used as calculators.

6. **Please submit the Answer Booklet at the end of the examination.** You may retain the Question Paper.

1. A block of mass $m = 0.1\,\text{kg}$ is attached to a spring (one end fixed to the wall) with spring constant $k = 50\,\text{N}\,\text{m}^{-1}$. The block slides on a rough horizontal table along the x-axis. Assume that both the coefficients of kinetic (μ_k) and static friction (μ_s) are same and constant ($\mu_k = \mu_s = \mu = 0.25$). The block is initially displaced to $x_0 = 0.1\,\text{m}$ from the unstretched position (normal length of the spring, $x = 0$) of the spring and released from rest as shown below. Neglect any air resistance. Take the acceleration g due to gravity to be $10\,\text{m/s}^2$.



   (a) **[3 marks]** How many times (n) will the block cross the unstretched position before coming to rest permanently?

   (b) **[1 marks]** Determine the total distance D covered by the block before coming to rest.

   (c) **[6 marks]** Let us divide one complete oscillation of the block, starting from a fully stretched condition of the spring, into four distinct sections, requiring the following times in order:

      (i) t_1: time taken for the block to move from fully stretched to the unstretched position,

      (ii) t_2: time taken for the block to move from the unstretched position to fully compressed position,

      (iii) t_3: time taken for the block to move from fully compressed to the unstretched position,

      (iv) t_4: time taken for the block to move from the unstretched position to fully stretched position.

   Let the distance covered during the above intervals be d_1, d_2, d_3, and d_4, respectively.

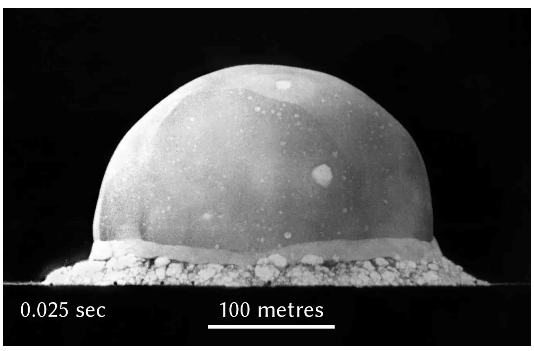
   Also, let T_1 and T_2 be the time taken to complete the first and the second oscillations, respectively, starting from the initial displacement, x_0.

   Compare the above times and distances by inserting an appropriate sign (from among <, >, or = only) between the given quantities in each of the boxes below. Note that you will be penalised for 0.5 marks for giving each incorrect answer in this part. You need not to justify your answer.

t_1		t_2	t_2		t_3	t_1		t_3
d_1		d_2	d_2		d_4	T_1		T_2

   (d) **[2 marks]** Qualitatively plot the displacement x from the unstretched position vs the time t.

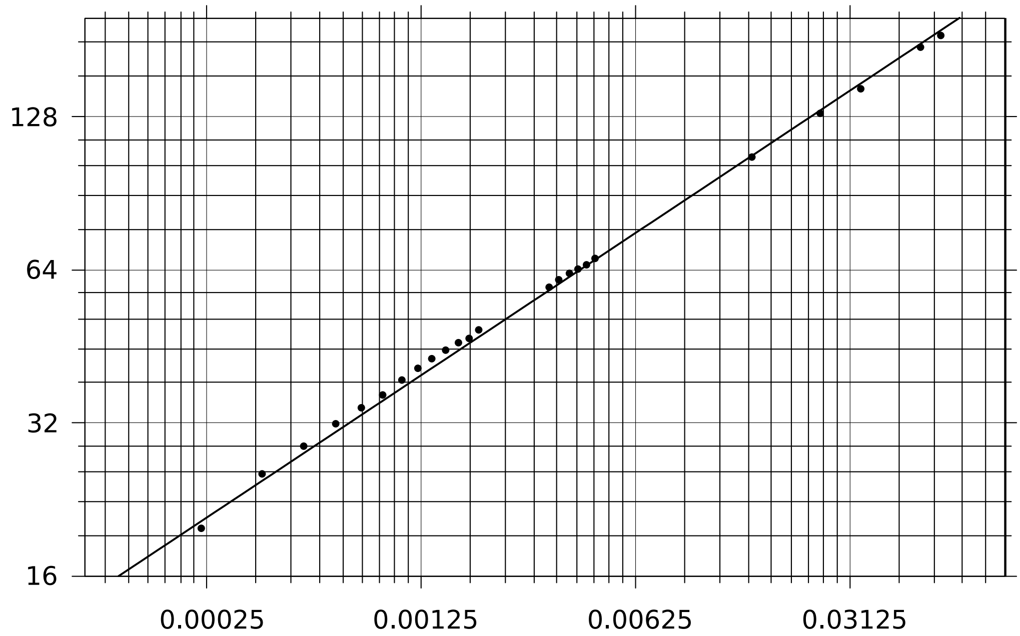
2. The first explosion of an atomic bomb was the Trinity test in New Mexico in 1945. This explosion released a very large amount of energy E which created an expanding fireball (known as the Trinity fireball). A snapshot of this fireball taken $0.025\,\text{s}$ after the explosion is shown in the photograph below.



A scientist, Prof. Geoffrey Taylor, could make an estimate of the energy released by the bomb from an analysis of such photographs. Here we try to follow in his footsteps, with some suitable simplifications.

To begin, we assume that the fireball is spherical in nature. Its radius (R) increases with time (t) depending on the explosion energy E and the density ρ of the surrounding air (which is taken as constant and uniform).

We are also given a graph of the data obtained by Prof. Taylor, as shown below. However, the axes labels of the graph are missing.



Given data:
1 kiloton (kt) of TNT $= 4.2 \times 10^{12}$ J
Density ρ of air outside the fireball $=1.22\,\mathrm{kg/m^3}$.

(a) [**3 marks**] What are the quantities represented by the axes of the graph? Also state the respective units in which they are expressed. In the detailed answer sheet, justify your answer.

(b) [**4 marks**] Find the slope (s) of the best fit line shown in the graph. What are the dimensions of the quantity s?

(c) [**3 marks**] From a dimensional analysis based on the above simplified model, make an estimate of the energy E released (in kt of TNT) in the Trinity test.

3. Consider an air filled spherical balloon comprised of elastic material of surface tension $\gamma = 500\,\mathrm{kg/s^2}$. The pressure outside the balloon is the atmospheric pressure ($P_{\mathrm{atm}} = 101\,\mathrm{kPa}$) and the density of air outside is $\rho_{\mathrm{atm}} = 1.22\,\mathrm{kg/m^3}$.

   The balloon starts deflating slowly. Assume that the average velocity of air inside the balloon is negligible, and air leaves the balloon in a streamline fashion. Consider γ to be constant throughout, and the air to be incompressible.

   (a) [**8 marks**] Write an expression for the time t required to deflate the balloon through a small opening of cross-sectional area A from an initial radius R_0 to a final radius R.

   (b) [**1 marks**] Obtain the value of this time for $A = 1 \times 10^{-5}\,\mathrm{m^2}$, $R_0 = 0.15\,\mathrm{m}$, and $R = 0.05\,\mathrm{m}$.

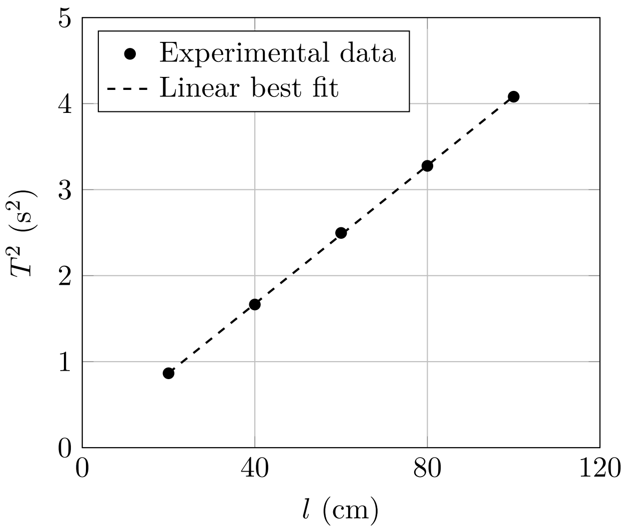
4. A student performed an experiment to determine the acceleration due to gravity (g) using a simple pendulum which has a spherical bob of diameter d hung with a long string. She varied the length

of the string l, and measured the period of oscillation T every time. She calculated the value of g from each measurement as shown in the table below.

She noticed that not only was the average value of g smaller than the expected value, each one of the measurements had yielded a value smaller than the true value.

Next, she plotted a graph between T^2 and l from the same data, and obtained the value of $g = 981\,\mathrm{cm/s^2}$ from the slope of the best fit line.

l (in cm)	T (in s)	g (in cm/s)
20	0.93	912
40	1.29	948
60	1.58	948
80	1.81	963
100	2.02	967
Average g		947

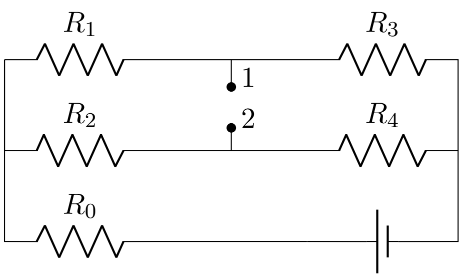


(a) **[3 marks]** What do you think might be the main cause for the consistently low values of g that she obtained from each of her measurements?

(b) **[4 marks]** Explain in detail why she still obtained a correct value of g from the slope of the graph plotted from the same data.

Assume that the instruments of measuring time and length were accurate enough, and all the measurements of the stated quantities were correct within the accuracy of the instruments. It is verified that the graph and the linear best fit were correctly plotted, and all numerical calculations in the above are correct. Note that you are not expected to plot any graph (no graph paper is provided to you).

5. **[12 marks]** A circuit consists of an emf source and five resistors with unknown resistances. When an ideal ammeter is connected between points 1 and 2, its reading is I_A. If instead a resistor R is connected to the same two points, the current through that resistor is I_R. If instead an ideal voltmeter is connected between points 1 and 2, its reading is V. Obtain V in terms of I_A, R and I_R only.



**** **END OF THE QUESTION PAPER** ****

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2022

Date of Examination: November 27, 2022
Time: 8:30 AM to 10:30 AM

Question Paper Code: 61

Student's Roll No:										

Write the question paper code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch, and ipad during examination is STRICTLY PROHIBITED.
2. In addition to this question paper, you are given OMR Answer Sheet along with Candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.

   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE** or **BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **Ten-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in NSE 2022.
6. Question paper has two parts. In part A1 (Q. No.1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative (s) and fill the appropriate bubble (s), as shown.

   Q.No.22 (a) ⬬ (c) (d)

   In part A2 (Q. No. 49 to 60) each question has four alternatives out of which any number of alternative (s) (1, 2, 3, or 4) may be correct. You have to choose all correct alternative(s) and fill the appropriate bubble(s), as shown

   Q.No. 54 (a) ⬬ (c) ⬬
7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Rough work may be done in the space provided. There are 15 printed pages in this paper
9. Use of **non - programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper & Candidate's copy OMR sheet for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued) :

You may read the following instructions after submitting the answer sheet.

12. Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iapt.org.in **on the specified format till December 3, 2022**

13. The answers/solutions to this question paper will be available on the website:
www.iapt.org.in **by December 2, 2022.**

14. CERTIFICATES and AWARDS:

Following certificates shall be awarded by IAPT to the students, successful in the NATIONAL STANDARD EXAMINATION IN PHYISCS – 2022

(i) CENTRE TOP 10 % To be downloaded from iapt.org.in after 15.01.23

(ii) STATE TOP 1 % Will be dispatched to the examinee

(iii) NATIONAL TOP 1 % Will be dispatched to the examinee

(iv) GOLD MEDAL & MERIT CERTIFICATE to all students who attend OCSC – 2023 at HBCSE Mumbai

Certificate for centre toppers shall be uploaded on iapt.org.in

15. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: www.iapt.org.in by **December 25, 2022. See the Minimum Admissible score Clause** on the Student's brochure on the web.

16. List of students eligible to appear for Indian National Physics Olympiad (INPhO – 2023) shall be displayed on www.iapt.org.in by December 30, 2022.

Physical constants you may need….

Magnitude of charge on electron $e = 1.60 \times 10^{-19}$C	Avogadro's constant $A = 6.023 \times 10^{23}$ mol^{-1}
Mass of electron $m_e = 9.10 \times 10^{-31}$ kg	Speed of light in free space $c = 3 \times 10^{8}$ m/s
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 / Nm^2
Acceleration due to gravity $g = 9.81$ ms^{-2}	Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H / m
Universal gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2 / Kg^2	Planck's constant $h = 6.625 \times 10^{-34}$ Js
Universal gas constant R = 8.31 J / molK	Faraday constant = 96,500 C / mol
Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K	Rydberg constant $R = 1.097 \text{ x } 10^{7}$ m^{-1}
Stefan's constant $\sigma = 5.67 \times 10^{-8}$ W / m^2 x K^4	Astronomical unit = $1.50 \text{ x } 10^{11}$ m

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS
(NSEP 2022)

Time: 120 minute **Max. Marks: 216**

Attempt All Sixty Questions

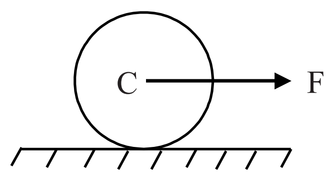
A - 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

1. A particle moves along a straight line. Its displacement S varies with time t according to the law $S^2 = at^2 + 2bt + c$ (a, b and c are constants). The acceleration of this particle varies as
(a) S^0 (b) S^{-1} (c) S^{-2} (d) S^{-3}

2. A ball A (mass m_1) moving with velocity v experiences an elastic collision with another stationary ball B (mass m_2). Each ball flies apart symmetrically relative to the initial direction of motion of ball A, at an angle θ. Ratio of the masses of balls $\frac{m_1}{m_2}$ is
(a) $1 + 2\cos\theta$ (b) $2\cos 2\theta$ (c) $1 + 2\cos 2\theta$ (d) $1 + \cos 2\theta$

3. A solid cylinder of mass m is rolling without slipping on a rough horizontal surface, under the action of a horizontal force F such that the line of action of F passes through centre C of the cylinder. Choose the correct alternative.
(a) Acceleration of centre of cylinder is $\frac{F}{m}$
(b) Frictional force on cylinder acts forward
(c) Magnitude of friction force is $\frac{F}{3}$
(d) None of the above.



4. A motor pump is used to deliver water at a certain rate r from a given pipe. To obtain thrice as much water from the same pipe in the same time, the power of the motor has to be increased to
(a) 3 times (b) 9 times (c) 27 times (d) 81 times

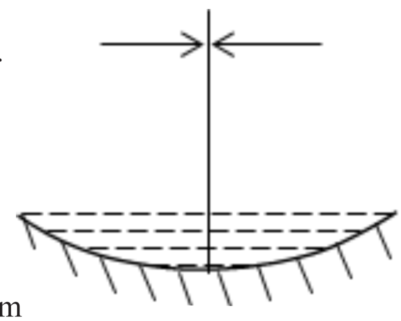
5. Two small solid balls of masses m and 8 m made up of same material are tied at the two ends of a thin weightless thread. They are dropped from a balloon in air. The tension T of thread during fall, after the motion of balls has reached steady state is
(a) 2 mg (b) 3.5 mg (c) 4.5 mg (d) zero

6. Obtain the value of $\frac{e^2}{2\epsilon_0 hc}$
(a) 0.0073 (b) 0.0073 m (c) 0.073 s^{-1} (d) 0.0346 m^{-1}

7. A sound source of fix frequency is in unison with an open end organ pipe of length 30.0 cm and a close end organ pipe of length 23.0 cm (both of same diameter). Both pipes are sounding their first overtone. If velocity of sound is 340 ms^{-1}, frequency of sound source is nearly
(a) 1000 Hz (b) 1062 Hz (c) 1100 Hz (d) 1018 Hz

8. Solar constant for Earth is 2.0 cal per cm^2 per minute. [1cal = 4.2 J]. Angular diameter of the Sun (as seen from the Earth) is $\frac{1°}{2}$ (= half a degree). Treating Sun as a black body, its surface temperature is estimated to be nearly
(a) 6000 K (b) 5800 K (c) 6200 K (d) 5500 K

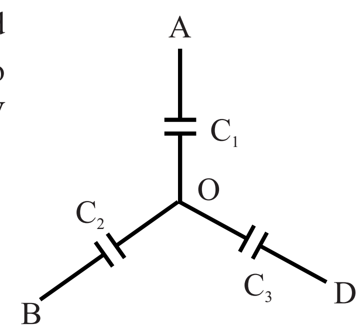
9. A concave mirror when placed in air has a focal length f = 20 cm. The mirror is now placed horizontally and filled with a thin layer of water having refractive index $\frac{4}{3}$. The object is placed horizontally near the principal axis at a distance d from the mirror such that a real, inverted image is formed at the same plane as the object, as shown in the figure. What is the value of d?



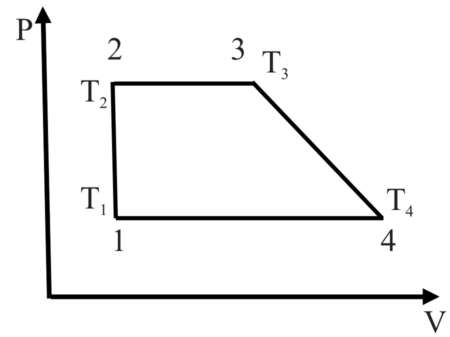
(a) 30 cm (b) 20 cm (c) 15 cm (d) 40 cm

10. When a sample of atoms is irradiated by neutrons, radioactive atoms are produced at a constant rate R, which decay with decay constant λ. The number of radioactive atoms accumulated after an irradiation time t is given by
(a) $N(t) = Rt\,e^{-\lambda t}$ (b) $N(t) = \frac{R}{\lambda} e^{-\lambda t}$
(c) $N(t) = \frac{R}{\lambda}\left(1 - e^{-\lambda t}\right)$ (d) $N(t) = Rt\left(1 - e^{-\lambda t}\right)$

11. Three uncharged capacitors of capacitances $C_1 = 2\mu F$, $C_2 = 3\mu F$ and $C_3 = 5\mu F$ are connected as shown in figure to one another at O and to points A, B and D at potentials $V_A = 300$ V, $V_B = 200$ V and $V_D = 400$ V respectively the potential V_O at O is
(a) 300 V (b) 320 V
(c) 240 V (d) 280 V



12. A cyclic process 1–2–3–4–1 consisting of two isobars 2 – 3 and 4 – 1, an isochor 1 – 2 and a process 3 – 4 represented by straight line on a P – V diagram, as shown in figure, involves n moles of an ideal gas. The gas temperatures at states 1, 2, 3 & 4 are T_1, T_2, T_3 and T_4 respectively. Also points 3 and 4 lie on the same isotherm. The work done by gas during the cycle is



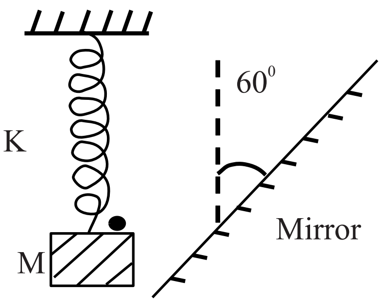
(a) $\frac{1}{2}nR\left(T_2 - T_1\right)\left(\frac{T_2}{T_1} + \frac{T_3}{T_4} - 2\right)$

(b) $\frac{1}{2}nR\left(T_3 - T_2\right)\left(\frac{T_3}{T_2} + \frac{T_4}{T_1} - 2\right)$

(c) $\frac{1}{2}nR\left(T_2 - T_1\right)\left(\frac{T_3}{T_1} + \frac{T_3}{T_2} - 2\right)$

(d) Zero

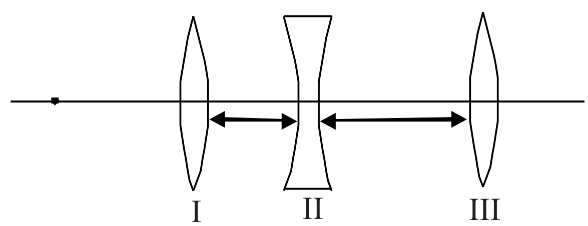
13. An insect of negligible mass is sitting on a block of mass M, tied with a spring of force constant K. The block performs simple harmonic motion vertically with amplitude A in front of a mirror which is inclined at 60^0 with the vertical as shown. The maximum speed of insect relative to its image will be



(a) $2A\sqrt{\frac{K}{M}}$ (b) $A\sqrt{\frac{3K}{M}}$

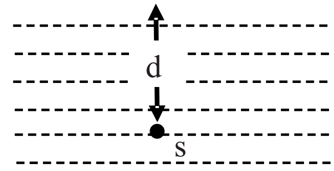
(c) $A\sqrt{\frac{K}{M}}$ (d) zero

14. A concave lens of focal length 10 cm is placed between two convex lenses of focal length 10 cm and 20 cm at a separation of 5 cm between the first and second lens and 10 cm between the second and third lens. An object is placed at 30 cm in front of the first convex lens. The final image is formed beyond the third lens at a distance v from it. Then



(a) v = 15 cm (b) v = ∞ (c) v = 45 cm (d) v = 20 cm

15. A point source S of light is placed at a depth d below the surface of water in a large and deep lake. Fraction of light that escapes in space above directly from water (refractive index = μ) surface is given by



(a) $\sqrt{1 - \frac{1}{\mu^2}}$ (b) $\frac{1}{2}\sqrt{1 - \frac{1}{\mu^2}}$

(c) $\frac{1}{2}\left\{1 - \sqrt{1 - \frac{1}{\mu^2}}\right\}$

(d) depends on d and increases with increasing d

16. A convex lens is held 45 cm above the bottom of an empty tank. The image of a point object at bottom of tank is formed 36 cm above the lens. Now a liquid is poured into the tank upto a height of 40 cm above the bottom. It is found that distance of image of same point object at the bottom of the tank is 60 cm above the lens. Refractive index of liquid is
(a) 1.33 (b) 1.37 (c) 1.40 (d) 1.60

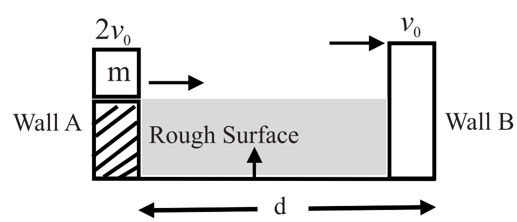
17. A potential of 5 V is applied across the faces of a pure germanium plate of area $2 \times 10^{-4}\,m^2$ and of thickness 1.2×10^{-3} m. Concentration of carriers in germanium at room temperature is $1.6 \times 10^{6}\,m^{-3}$, Mobility of electrons and holes are $0.4\ m^2 V^{-1} s^{-1}$ and $0.2\ m^2 V^{-1} s^{-1}$ respectively. The current produced in germanium plate at room temperature, is
a) 1.28×10^{-13} A (b) 1.28×10^{-9} A (c) 1.536×10^{-13} A (d) 6.4×10^{-10} A

18. Fission of one nucleus of ^{235}U releases 200 MeV energy in average. Minimum amount of ^{235}U required to run 1000 MW reactor per year of continuous operation (assuming 30% efficiency) is
(a) 1280 ton (b) 1.28 ton (c) 1.1 ton (d) 1.1×10^{5} ton

19. In a young's double slit experiment distance between slits is d = 1 mm, Wavelength of light used is 600 nm and distance of screen from the plane of slits is D = 1 m. The minimum distance between two points on the screen where intensity falls to 75 % of maximum intensity will be (Assume both sources of equal power).
(a) 0.1 mm (b) 0.2 mm (c) 0.45 mm (d) 0.9 mm

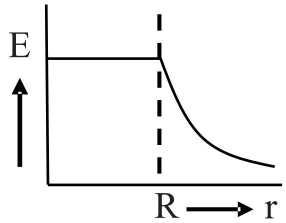
20. A ball is projected from horizontal ground. It attains a maximum height H on its projectile path and there after strikes a stationary smooth vertical wall and falls on ground vertically below the point of maximum height. Assume the collision with wall to be perfectly elastic, the height of the point on the wall where the ball strikes is
(a) $\frac{3H}{4}$ (b) $\frac{2H}{3}$ (c) $\frac{H}{2}$ (d) $\frac{4H}{5}$

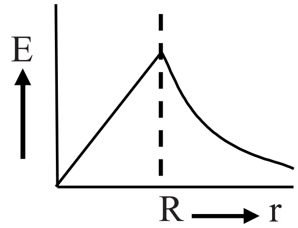
21. As shown in figure, a block of mass m is projected from wall A with velocity $2v_0$ on the rough surface with constant sliding friction to hit the wall B with velocity v_0. With what velocity same mass m should be projected to hit the wall B with same velocity v_0 if the surface is now moving upward with an acceleration of $a = 4g$?

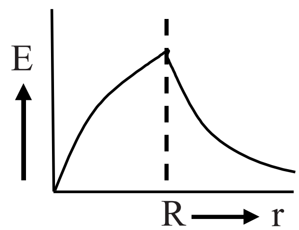


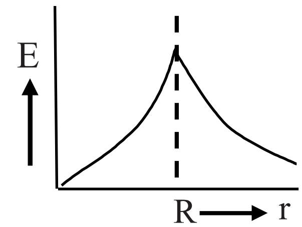
(a) $2\,v_0$ (b) $3\,v_0$ (c) $4\,v_0$ (d) $5\,v_0$

22. A sphere of radius R, is charged with volume charge density ρ such that $\rho \propto r$ (r is distance from centre). Variation of electric field E with r (For all values of r : $r \leq R$ and $r > R$) is best represented by

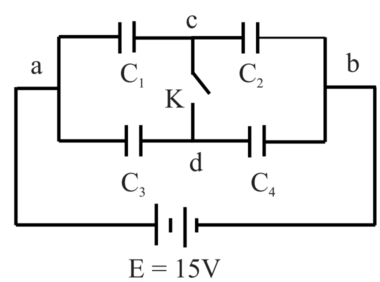
(a) 

(b) 

(c) 

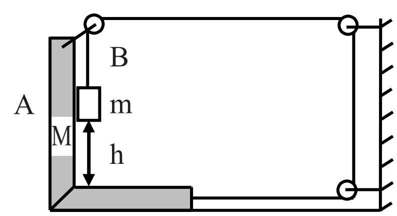
(d) 

23. A system of capacitors $C_1 = 4\,\mu F$, $C_2 = 1\,\mu F$, $C_3 = 2\,\mu F$ and $C_4 = 3\,\mu F$ connected across a battery of emf E = 15V is shown in figure. The charge that will flow, through the switch K, when it is closed, is



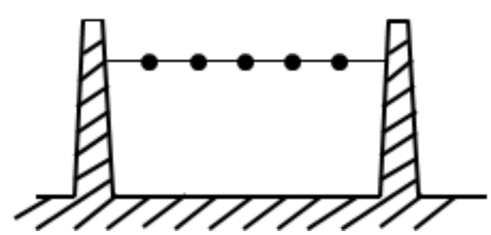
(a) $15\,\mu C$ c to d
(b) $12\,\mu C$ c to d
(c) $6\,\mu C$ d to c
(d) $9\,\mu C$ d to c

24. A simplification of a kind of interlock is shown in figure. All surfaces are smooth and frictionless. The body m has a mass m = 1 kg and the block M = 15 kg. The time 'm' takes to reach the base if it is released at height h = 4 meter above the base of M, is [use $g = 10\,ms^{-2}$]



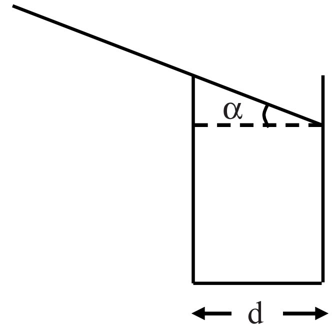
(a) 1 s
(b) $\sqrt{3}$ s
(c) 2 s
(d) $2\sqrt{2}$ s

25. A number n of identical balls, each of mass *m* and radius r, are stringed like beads at random and at rest along a smooth, rigid horizontal rod of length L mounted between immovable supports; $\frac{r}{L}$ is small but not negligible. Collision between balls, or between balls and supports, are perfectly elastic. One of the balls is struck horizontally so as to acquire a speed *v*. Resulting outward force felt by supports, averaged over a long time, is



(a) $\frac{mv^2}{2(L-2nr)}$ (b) $\frac{mv^2}{(L-2nr)}$ (c) $\frac{2mv^2}{(L-2nr)}$ (d) $\frac{mv^2}{L}$

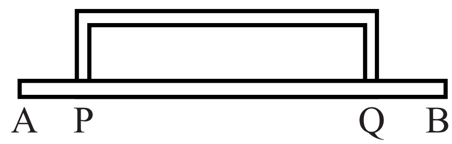
26. A cylindrical tumbler of diameter d has smooth sides and smooth edge. A thin rod of length L is balanced on the edge of the tumbler as shown in figure. The angle α that the rod makes with horizontal for this trick to work is



(a) $\sin^{-1}\left(\frac{d}{L}\right)^{\frac{1}{2}}$ (b) $\cos^{-1}\left(\frac{2d}{L}\right)^{\frac{1}{3}}$

(c) $\cos^{-1}\left(\frac{d}{L}\right)^{\frac{1}{3}}$ (d) $\sin^{-1}\left(\frac{2d}{L}\right)^{\frac{1}{3}}$

27. End A of a uniform thin rod of length 2L is in boiling water (100^0C) and end B is in melting ice (0^0C). P and Q are two points at distance $\frac{L}{2}$ from A and B respectively. A similar bent rod of length $\frac{3L}{2}$ of same material and equal cross section is joined to rod AB between points P and Q as shown in figure. Then

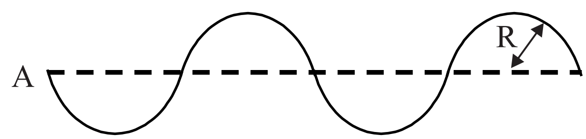


(a) Temperature at P will increase and that at Q will decrease
(b) Rate of flow of heat will increase by 25%
(c) Rate of flow of heat will decrease by 20%
(d) Rate of heat flow will increase by 37.5%

28. Two stars of masses M and m (M = 2 m) separated by a distance d = 3 astronomical unit, revolve in circular orbit about their centre of mass with a period of 2 years. If M_s is mass of Sun then

(a) $m = 2.25\,M_s$ (b) $m = 1.25\,M_s$ (c) $m = 2.50\,M_s$ (d) $m = 4.50\,M_s$

29. A thin uniform rod of mass M is bent in to four adjacent semicircles of radius of curvature R lying in same plane. Moment of inertia of the bent rod about an axis through one end A and perpendicular to plane of the rod is



(a) $\frac{17}{2}MR^2$ (b) $44\,MR^2$

(c) $22\,MR^2$ (d) $\frac{43}{2}MR^2$

30. Three point charges + q, – 2q and + q are placed on x – axis at x = – d, x = 0 and x = + d respectively. The value of electric field at a point P on x axis at x = r (r >> d) is given by $E = \frac{1}{4\pi\varepsilon_0}\frac{aQ}{r^n}$ (Here $Q = 2qd^2$) Then

(a) a = 3, n = 3 (b) a = 6 , n = 4 (c) a = 3, n = 4 (d) $a = \frac{3}{2}$, n = 4

31. The frequency of the transverse oscillations of a proton (mass M) trapped in a cylindrical relativistic electron beam of circular cross section of radius R and current I is given by [assume that speed v of relativistic electrons $\approx c$ (the speed of light in vacuum) and ignore magnetic effect]

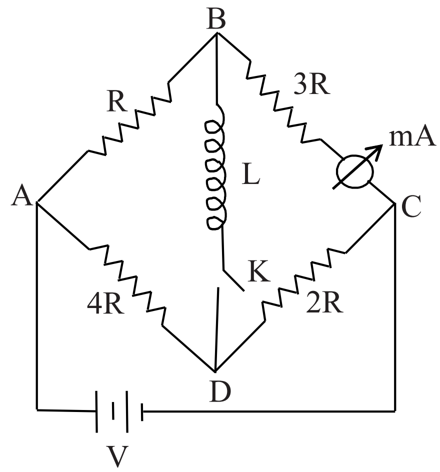
(a) $\frac{1}{2\pi R}\sqrt{\frac{eI}{2\pi\varepsilon_0 Mc}}$ (b) $\frac{1}{2\pi R}\sqrt{\frac{2\pi\varepsilon_0 I}{Mc}}$

(c) $\frac{1}{R}\sqrt{\frac{2\pi\varepsilon_0 Mc}{eI}}$ (d) $\frac{1}{2\pi\varepsilon_0}\sqrt{\frac{2\pi\varepsilon_0 Mc}{eI}}$

32. Current I flows through a long thin walled metallic cylinder of radius R with a thin longitudinal slit of width ξ (ξ<<R) running parallel to the axis of the cylinder. The magnetic induction **B** produced at any point on the axis of the cylinder is approximately

(a) $\mathbf{B}$ = zero   (b) $\mathbf{B} = \frac{\mu_0 I}{2\pi R^2}$ (c) $\mathbf{B} = \frac{\mu_0 I\xi}{4\pi^2 R^2}$ (d) $\mathbf{B} = \frac{\mu_0 I\xi}{2\pi R^2}$

33. The reading of the ammeter, used in the electrical network shown below, is 20 mA, a long time after the key K is closed



The reading of the same ammeter, immediately after the key was closed was

(a) zero   (b) 16 mA   (c) 25 mA   (d) 32 mA

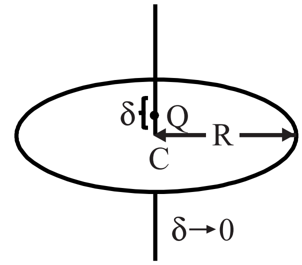
34. At the Earth's surface, a projectile is launched straight up at a speed of 10.0 km/s. Height to which it will rise is [g at surface of Earth = 9.8 ms^{-2} and radius of earth R = 6400 km]

(a) 1.63×10^3 km   (b) 1.56×10^4 km   (c) 2.52×10^4 km   (d) 5.1×10^3 km

35. A small sphere of mass 2.00 g is released from rest in a large cylindrical vessel filled with oil. The resistive force due to viscosity of oil acting on sphere is proportional to its velocity. Sphere approaches a terminal speed of 5.00 cm/s. The time it takes the sphere to reach 90.0% of its terminal speed is approximately.

(a) 3.22 ms   (b) 5.10 ms   (c) 10.2 ms   (d) 11.7 ms

36. A static point charge Q is located just above the centre C ($\delta \rightarrow 0$) of a horizontal circle of radius R on its geometric axis, as shown in figure. The magnitude of electric flux through this circle is



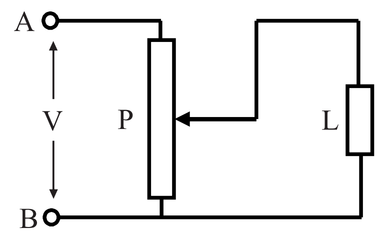
(a) Zero (b) $\frac{Q}{4\varepsilon_0}$

(c) $\frac{Q}{2\varepsilon_0}$ (d) $\frac{Q}{\varepsilon_0}$

37. Three small identical neutral metal balls are at the vertices of an equilateral triangle. The balls are in turn touched to an isolated large charged conducting sphere whose centre is on a line perpendicular to the plane of triangle and passing through its centre. As a result the first and second balls have acquired charges q_1 and q_2 respectively. The charge acquired by the third ball is [Assume that charge and potential of large spherical conductor change insignificantly in charging of the balls and that charges on balls are spherically symmetric]

(a) $\frac{q_1^2}{q_2}$ (b) $\frac{q_2^2}{q_1}$ (c) $2q_2 - q_1$ (d) $q_3 = q_2 = q_1$

38. Voltage across the load L is controlled by using circuit as shown in figure. P is a potentiometer. Resistance R_L of the load and R_P of the potentiometer are equal to R. Load L is connected to the middle of potentiometer. Input voltage V is constant. If now R_L is doubled, the voltage across load will change by a factor



(a) $\frac{5}{4}$ (b) $\frac{7}{5}$ (c) $\frac{8}{9}$ (d) $\frac{10}{9}$

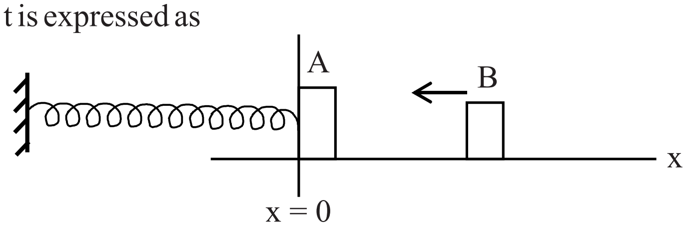
39. A small block A of mass 2 kg is attached to a spring of force constant 1200 Nm^{-1}, and rests on a smooth horizontal surface at $x = 0$ as shown in figure. A second block B of mass 1kg slides along the surface towards A at 6 ms^{-1} and sticks to it. Assuming that the collision occurs at $t = 0$, position x (in meter) of block A as a function of time t is expressed as

(a) $x = 0.173 \cos 20\,t$

(b) $x = 0.1 \cos 40\pi\,t$

(c) $x = -0.173 \sin \frac{\pi}{10}\,t$

(d) $x = -0.1 \sin 20\,t$



40. Two plane glass testing slides each of surface area A are stuck with each other by a small water drop squeezed between them as an extremely thin film of thickness d. If the surface tension of water be T and the angle of contact be zero, then the force required to pull apart the two glass plates will be

(a) $\frac{8TA}{d}$ (b) $\frac{4TA}{d}$ (c) $\frac{2TA}{d}$ (d) $\frac{TA}{d}$

41. The rate of flow of a certain liquid of viscocity η through a horizontal capillary of length l and radius r is Q when the pressure head at the inlet is just twice the atmospheric pressure. The rate of flow of the same liquid through another capillary of length $2l$ and radius $2r$ when the inlet pressure head is 4 times the atmospheric pressure will be (The outlet being open to atmosphere in each case)
(a) 24 Q (b) 16 Q (c) 8 Q (d) 4Q

42. A uniform rod of the material of Young's modulus Y is pushed over a smooth horizontal surface by a constant horizontal force F. The area of cross - section of the rod is A. The compressional strain in the rod is
(a) $\frac{F}{AY}$ (b) $\frac{F}{2AY}$ (c) $\frac{3F}{2AY}$ (d) $\frac{2F}{AY}$

43. A total charge Q is uniformly distributed over a non – conducting ring of radius r. There is a time varying magnetic field perpendicular to its plane and changing at the uniform rate of $\frac{dB}{dt}$. The magnitude of induced tangential electric field E on ring is
(a) $r\frac{dB}{dt}$ (b) $r^2\frac{dB}{dt}$ (c) $\frac{1}{2}r\frac{dB}{dt}$ (d) $\frac{1}{2}r^2\frac{dB}{dt}$

44. DC *emf* of 15 V is applied to a circuit containing 5 H inductance and 10 Ω resistance in series at t = 0. The ratio of the currents in the circuit at t = 0.5 sec and at t = 1.0 sec is
(a) $\frac{e^2}{e^2-1}$ (b) $\frac{\sqrt{e}}{\sqrt{e}-1}$ (c) $\frac{e}{e+1}$ (d) $\frac{1}{e}$

45. An insulating rod of length ℓ carries a charge q distributed uniformly all over its length. The rod is pivoted at its midpoint and is rotated at a frequency f (in Hz) about an axis perpendicular to the rod passing through the point at the pivot. The magnetic moment of the system is
(a) $\frac{1}{12}\pi q f \ell^2$ (b) $\frac{1}{6}\pi q f \ell^2$ (c) $\frac{1}{3}\pi q f \ell^2$ (d) $\pi q f \ell^2$

46. A circular loop of radius r is placed inside another circular loop of radius R ($R >> r$). The loops are coplanar and concentric. The mutual inductance (M) of the system is proportional to
(a) $\frac{r}{R}$ (b) $\frac{r^2}{R}$ (c) $\frac{R^2}{r}$ (d) $\frac{r^2}{R^2}$

47. The amplitude of the electric and magnetic fields associated with a beam of light of intensity 477.9 W/m^2 are, respectively,
(a) 6×10^2 V / m and 2×10^{-6} T (b) 3×10^2 V / m and 1×10^{-6} T
(c) 12×10^2 V / m and 4×10^{-6} T (d) 9×10^2 V / m and 3×10^{-6} T

48. Given that the critical angle of incidence for total internal reflection within a transparent material when placed in air is 45°. The Brewster's angle of incidence for light propagating from air to the transparent material will be
(a) 54.74° (b) 35.26° (c) 25.26° (d) 44.74°

A – 2

ANY NUMBER OF OPTIONS 4, 3, 2 or 1 MAY BE CORRECT

MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED.

49. A hydrogen atom is in ground state (n = 1). The magnetic field produced by revolving electron, at centre of atom is B_0. Atom is excited to state n = 4. According to Bohr model, the correct alternative(s) is/are

(a) Magnetic field at centre of atom for (n = 4) becomes $B_4 = \frac{B_0}{64}$

(b) Energy absorbed by atom in going from (n = 1) to (n = 4) is 12.75 eV

(c) Change in magnitude of angular momentum of electron is $\frac{3h}{2\pi}$

(d) Assume that this excited atom (n = 4) is at rest and it makes transition to ground state (n = 1) in a single quantum jump of an electron, (Take mass of atom $M_H = 1.67 \times 10^{-27}$ Kg) the recoil speed of atom will be nearly $v = 4.1\ ms^{-1}$.

50. In an experimental set up to study the photoelectric effect a point source of light of power 3.2 mW is used. The source emits mono energetic photons of energy 5 *eV* and is located at a distance d = 0.8 m from centre of a stationary metallic sphere of work function W = 3.0 *eV*. The radius of the sphere is R = 8 mm. Assume that the sphere is isolated and photo electrons are instantly swept away after emission. Also assume that the efficiency of photoelectric emission is one for every 10^6 photons. In the present set up

(a) The de Broglie wave length of fastest moving photoelectron is nearly $8.7\ A^0$

(b) It is observed that after some time emission of photoelectrons from the surface of metal sphere is stopped, the charge on sphere just when the electron emission stops is $64\pi\epsilon_0 \times 10^{-3}$ C

(c) Time after which photo electric emission stops is nearly 111 s

(d) The light source emits 4×10^{15} photons per sec

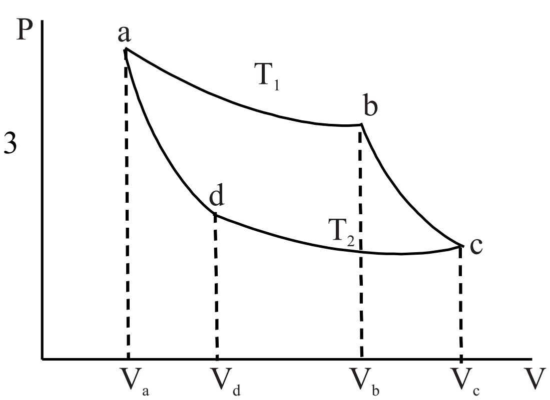
51. Two identical Carnot (cycles) engines operate between maximum and minimum temperatures T_1 and T_2 and volume limits, V_a, V_b, V_c & V_d as shown in figure. Given that $\frac{V_c}{V_a} = e^3$ and $\frac{T_1}{T_2} = e$ (e is the base of natural logarithm). Engine 1 operates on mono atomic gas while the engine 2 on diatomic gas. Choose correct alternatives

(a) Ratio of volumes $\frac{V_{b,1}}{V_{b,2}} = e$

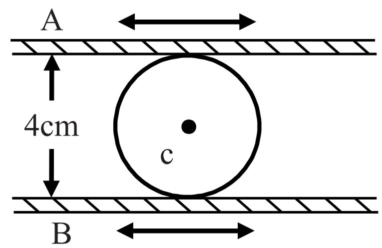
(b) Ratio of work done per cycle for the two is $\frac{W_1}{W_2} = 3$

(c) Ratio of work per cycle for the two is $\frac{W_1}{W_2} = 1$

(d) Ratio of efficiencies (η) of two engines $\frac{\eta_1}{\eta_2} = 1$

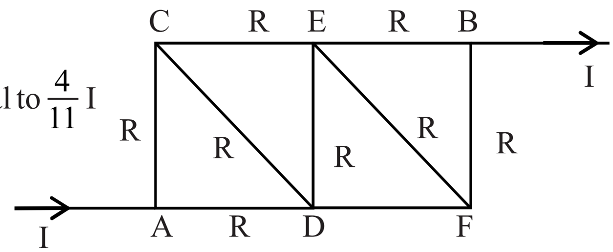


52. In a certain machine two steel plates are separated by a hardened steel cylindrical roller (see fig). In operation, the plates move back and forth horizontally, perpendicular to the axis of roller, and the roller rolls freely between plates without slipping on either one. At a particular instant plate A is moving with a speed of 18 cm sec^{-1} to the right and an acceleration of 30 cm sec^{-2} to the left, and the plate B is moving with a speed of 6 cm sec^{-1} to the right and an acceleration of 8 cm sec^{-2} to the left. At that instant, for the roller



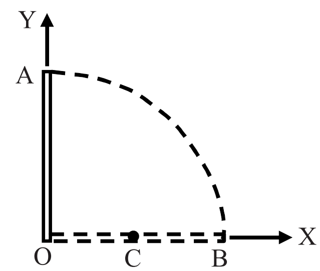
(a) Its angular speed is 3 rad sec^{-1} clockwise
(b) Its angular acceleration is 6 rad sec^{-2} clockwise
(c) The liner speed of its axis is 12 cm sec^{-1} towards right
(d) The linear acceleration of its axis is 20 cm sec^{-2} towards left

53. Each of 9 sides of frame A C D E F B has resistance *R* (Nine in all) A current *I* enters at A and leaves at B. Choose the correct alternatives.



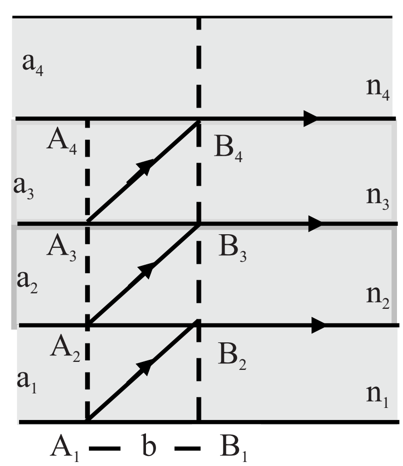
(a) Currents in branches CD and EF are zero.
(b) Currents in branches CE and DF are each equal to $\frac{4}{11}$ I
(c) Effective resistance between A and B is $\frac{15}{11}$R
(d) Effective resistance between A and B is $\frac{3}{4}$R

54. A long uniform rod of length L and mass M is pivoted vertically on a horizontal, friction less pivot at its lower end. The rod is released from rest in its vertical position OA (see figure). It falls off without slipping at O. At the instant the rod is horizontal,



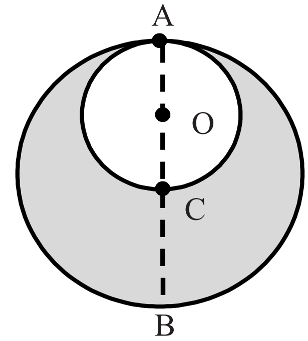
(a) Its angular speed is $\sqrt{\frac{3g}{L}}$
(b) Magnitude of its angular acceleration is $\frac{3g}{2L}$
(c) Acceleration of its centre of mass $\vec{a}_{CM} = -\frac{3g}{4}\hat{j}$ ($\hat{j}$ unit vector in Y direction)
(d) Reaction force at pivot = $\frac{Mg}{4}\hat{j}$ (Take X, Y axis as shown)

55. There are four layers of glass plates, placed on top of each other such that bottom one has thickness a_1 and refractive index $n_1 = 2.7$. Next one has thickness a_2 and refractive index $n_2 = 2.43$. The third one and the top one have thickness a_3 and a_4 and refractive indices n_3 and n_4 respectively. Three rays starting at the same moment from A_1, A_2 and A_3 reach points B_2, B_3, B_4 at the same time, with their angles of incidence being critical angle. You are given $A_1B_1 = A_2B_2 = A_3B_3 = A_4B_4 = b = 10$ mm. Choose correct statement (s).



(a) $n_3 = 1.968$ (b) $n_4 = 1.291$
(c) $a_2 = 7.243$ mm (d) $a_3 = 11.51$mm
[In four significant figures]

56. In an isolated asteroid of radius R and uniform density ρ, a spherical cavity of diameter AC = R is excavated, where C is centre of asteroid. Choose correct alternative (s)



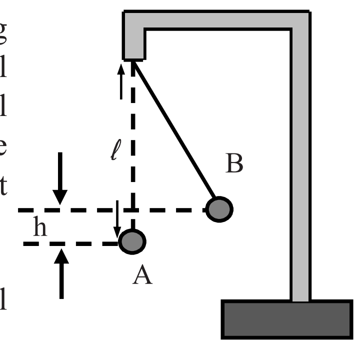
(a) A ball just dropped from A will strike C with speed $v = 2R\sqrt{\frac{\pi \rho G}{3}}$

(b) A ball dropped from A will reach C after time $t = \sqrt{\frac{3}{\pi \rho G}}$

(c) Acceleration of ball dropped from A varies as its distance from O (centre of cavity)

(d) Weight of a body placed at B (diametrically opposite to A) on surface of asteroid decreases by a factor $\frac{7}{8}$ due to excavation of cavity.

57. A small positively charged ball of mass m is suspended by a long insulating thread of negligible mass. Other positively charged small ball is moved very slowly from a large distance (along horizontal direction) until it is at original position A of first ball. As a result the first ball rises by h to position B such that h << ℓ. Choose the correct statement (s)



(a) Electrostatic energy of system of charges is 2 mgh.
(b) Total work done on system to bring two balls in their final position is mgh.
(c) Total work done on the system to bring two balls in their final position is 3 mgh.
(d) Work done on system to bring two balls in their final position does not depend on the magnitude of charges explicitly.

58. A rope of mass *m* and length L is suspended vertically. A mas *M* is suspended from bottom of the rope. A transverse wave is produced on the rope, which travels the length of rope in time *t* choose the correct statement (s)

(a) $t = 2\sqrt{\frac{L}{mg}}\left(\sqrt{M+m} - \sqrt{M}\right)$

(b) For $m << M$ The time $t = \sqrt{\frac{mL}{Mg}}$

(c) For $M = 0$ (i.e. no mass hanging) the time $t = \sqrt{\frac{L}{g}}$

(d) Time to travel the lower half of the rope by the wave is less than that to travel the upper half.

59. A long solenoid having 1000 turns per meter carries a current of 1A. It has a soft iron core of $\mu_r = 1000$. The core is heated beyond the Curie temperature (T_C). Then
(a) The H field in the solenoid is nearly unchanged but the B field decreases drastically.
(b) The H and B fields in the solenoid are nearly unchanged.
(c) The magnetization in the core reverses direction.
(d) The magnetization in the core diminishes by a factor of about 10^8

60. A thin and infinitely long metal sheet of appreciable finite width b carrying current I (distributed uniformly through out of its cross section) parallel to its length is placed in an external magnetic field B_e parallel to its plane and perpendicular to the direction of current

(a) The thin metal sheet experiences a mechanical pressure $P = \frac{IB_e}{b}$ perpendicular to its face.

(b) The direction of the pressure does not change if the direction of current is reversed.

(c) In case the external magnetic field B_e is switched off, a magnetic field $B = \frac{\mu_0 I}{2b}$ is observed parallel to the plane of the sheet but perpendicular to the direction current.

(d) The magnetic field produced in part (c) is $B = \frac{2\mu_0 I}{b}$

Rough Work

INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Standard Examination in Physics - 2023

Date of Examination: November 26, 2023
Time: 8:30 AM to 10:30 AM

Question Paper Code: 61

Student's Roll No:										

Write the Question Paper Code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the Question Paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch, and iPad during examination is STRICTLY **PROHIBITED.**
2. In addition to this Question Paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the Answer Sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **Ten-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials (means login id and password, respectively) for accessing your performance / result in National Standard Examination in Physics – 2023.
6. Question Paper has two parts. In part A1 (Q. No.1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   Q.No.22 (a) ● (c) (d)

   In part A2 (Q. No. 49 to 60) each question has four alternatives out of which any number of alternative (s) (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternative(s) and fill the appropriate bubble(s), as shown

   Q.No.54 (a) ● (c) ●
7. For **Part A1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2,** you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Rough work may be done in the space provided. There are **13** printed pages in this paper
9. Use of **Non - programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting Answer Paper, take away the Question Paper & candidate's copy of OMR sheet for your future reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR Answer Sheet.

Answer Sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (Continued) :
You may read the following instructions after submitting the Answer Sheet.

12. **Comments/Inquiries/Grievances regarding this Question Paper, if any, can be shared on the Inquiry/Grievance column on www.iapt.org.in on the specified format till Dec 3, 2023**

13. **The Answers/Solutions to this Question Paper will be available on the website: www.iapt.org.in by Dec 2, 2023.** The score card may be downloaded after Dec 24, 2023

14. **CERTIFICATES and AWARDS:**
Following certificates shall be awarded by IAPT to the students, successful in the NATIONAL STANDARD EXAMINATION IN PHYISCS – 2023
(i) "CENTRE TOP 10 %" To be downloaded from iapt.org.in after 30.01.24
(ii) "STATE TOP 1 %" Will be dispatched to the examinee
(iii) "NATIONAL TOP 1 %" Will be dispatched to the examinee
(iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC – 2024 at HBCSE Mumbai
Certificate for centre toppers shall be uploaded on iapt.org.in

15. List of students (with centre number and roll number only) having score above **Minimum Admissible Score** (MAS) will be displayed on the website: **www.iapt.org.in** by **Dec 26, 2023. See the MAS clause** on the Student's brochure on the web.

16. List of students eligible to appear for Indian National Physics Olympiad (INPhO – 2024) shall be displayed on **www.iapt.org.in** by Dec 30, 2023.

Physical constants you may need….

Magnitude of charge on electron $e = 1.60\times10^{-19} C$	Avogadro's constant $A = 6.023\times10^{23} mol^{-1}$
Mass of electron $m_e = 9.11\times10^{-31} kg$	Speed of light in free space $c = 3\times10^{8}\ ms^{-1}$
Mass of proton $m_p = 1.67\times10^{-27} kg$	Speed of sound in dry air at 0°C $v = 332\ ms^{-1}$
Acceleration due to gravity $g = 9.81\ ms^{-2}$	Permittivity of free space $\varepsilon_0 = 8.85\times10^{-12} C^2/Nm^2$
Universal gravitational constant $G = 6.67\times10^{-11} Nm^2/kg^2$	Permeability of free space $\mu_0 = 4\pi\times10^{-7}\ Hm^{-1}$
Universal gas constant $R = 8.31\ J/mol\,K$	Planck's constant $h = 6.625\times10^{-34}\ Js$
Boltzmann constant $k = 1.38\times10^{-23} J/\mathrm{K}$	Faraday constant $= 96,500\ C\,mol^{-1}$
Stefan's constant $\sigma = 5.67\times10^{-8} W/m^2K^4$	Rydberg constant $R = 1.097\times10^{7} m^{-1}$
Atmospheric pressure (at STP) = 1.013×10^{5} Nm^{-2}	Astronomical unit $= 1.50\times10^{11}\ m$

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS
(NSEP – 2023)

Time: 120 minute **Max. Marks: 216**

Attempt All the Sixty Questions

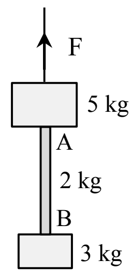
A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

1. Two balls are projected from the top of a cliff with equal initial speed u. One starts at angle θ above the horizontal while the other starts at angle θ below. Difference in their ranges on ground is

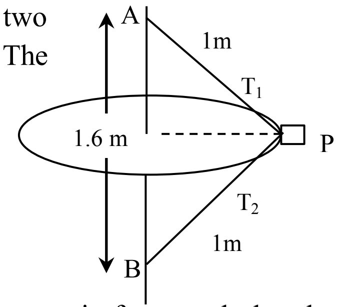
(a) $2\frac{u^2 \tan\theta}{g}$ (b) $\frac{u^2 \sin 2\theta}{2g}$ (c) $\frac{u^2 \sin 2\theta}{g}$ (d) $\frac{u^2 \cos 2\theta}{g}$

2. A solid block of mass 3 kg is suspended from the bottom of a 5 kg block with the help of a rope AB of mass 2 kg as shown in the figure. When pulled by an upward force F, the whole system experiences an upward acceleration $a = 2.19\ ms^{-2}$. Choose the correct option



(a) Net force on the rope AB is 24 N
(b) Tension at the midpoint of the rope AB is 48 N
(c) Force F is 20 N
(d) Force F is 60 N

3. A block P of mass 0.4 kg is attached to a vertical rotating spindle by two strings AP and BP of equal length 1.0 m as shown in the figure. The period of rotation is 1.2 s. Tensions T_1 and T_2 in string AP and BP are



(a) T_1 = 15.86 N T_2 = 10.97 N
(b) T_1 = 15.86 N T_2 = 3.04 N
(c) T_1 = 7.94 N T_2 = 3.03 N
(d) $T_1 = T_2$ = 5.48 N

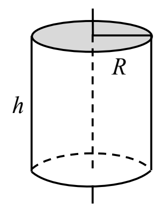
4. A particle of mass m moves in a straight line under the influence of a certain force such that the power (P) delivered to it remains constant. Starting from rest, the straight line distance traveled by the moving particle in time t is

(a) $\left(\frac{8Pt^3}{27m}\right)^{\frac{1}{2}}$ (b) $\left(\frac{4Pt^3}{27m}\right)^{\frac{1}{2}}$ (c) $\left(\frac{8Pt^2}{9m}\right)^{\frac{1}{2}}$ (d) $\left(\frac{8Pt^3}{9m}\right)^{\frac{1}{2}}$

5. A bullet is fired vertically up with half the escape speed from the surface of the Earth. The maximum altitude reached by it (ignore the effect of rotation of the Earth) in terms of radius of Earth R is

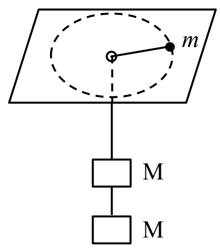
(a) $\frac{R}{3}$ (b) $\frac{R}{2}$ (c) R (d) $\frac{2R}{3}$

6. A **can** is a hollow cylinder of radius R and height h. Its ends are sealed with circular sheets of the same material. The can is made of thin sheet metal of areal mass density $\sigma\,(kg/m^2)$. Moment of inertia of this closed **can** about its vertical axis of symmetry is



(a) $\pi R^3\sigma(h+2R)$ (b) $\pi R^3\sigma(h+R)$
(c) $\pi R^3\sigma(2h+R)$ (d) $2\pi R^3\sigma(h+R)$

7. A particle of mass m is revolving in a horizontal circle on a frictionless horizontal table with the help of a string tied to it and passing through a hole at the center of the table. Two equal masses M are attached to the other end of the string as shown. If one of the hanging masses M is removed gently, the radius of the circular motion of m



   (a) decreases by a factor 1.414
   (b) increases by a factor 1.260
   (c) increases by a factor 1.414
   (d) does not change because of the conservation of angular momentum.

8. Three stars of equal mass M rotate in a circular path of radius r about their center of mass such that the stars always remain equidistant from each other. The common angular speed (ω) of rotation of the stars can be expressed as

   (a) $\left(\frac{GM\sqrt{3}}{r^3}\right)^{\frac{1}{2}}$ (b) $\left(\frac{GM}{r^3}\right)^{\frac{1}{2}}$ (c) $\left(\frac{GM}{r^3}\frac{2}{\sqrt{3}}\right)^{\frac{1}{2}}$ (d) $\left(\frac{GM}{r^3\sqrt{3}}\right)^{\frac{1}{2}}$

9. The density of a liquid is ρ at the surface. The bulk modulus of the liquid is B. The increase Δρ in the density of the liquid at a depth h from the surface is (with $\Delta\rho << \rho$)

   (a) $\Delta\rho = \frac{\rho^2 g h}{B}$ (b) $\Delta\rho = \frac{\rho g h}{B}$ (c) $\Delta\rho = \frac{\rho^2 g h}{2B}$ (d) $\Delta\rho = \frac{2\rho^2 g h}{B}$

10. Water flows at 1.2 m/s through a hose of diameter 1.59 cm. The time required to fill a cylindrical container of radius 2 m to a height of h = 1.25 m will be nearly
    (a) 18.3 hour (b) 2.7 hour (c) 550 min (d) 220 min

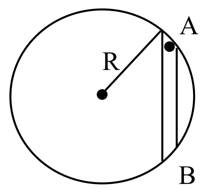
11. A police car, moving at speed of 108 km/hour, approaches a truck moving at 72 km/hour in opposite direction. The natural frequency of the siren of the car is 800 Hz and the surrounding temperature is 27°C. The frequency heard by the truck driver as the car passes him
    (a) remains unchanged (b) decreases nearly by 232 Hz
    (c) increases nearly by 231 Hz (d) decreases nearly by 260 Hz

12. A rope of mass M and length L hangs vertically. Time needed for a transverse pulse to travel from its bottom end to the support is

    (a) $\sqrt{\frac{2L}{g}}$ (b) $2\sqrt{\frac{L}{g}}$ (c) $\sqrt{\frac{L}{g}}$ (d) $\sqrt{\frac{L}{2g}}$

13. The figure shows a smooth tunnel AB $(length = 2\ell)$ in a uniform density planet (say Earth) of mass M and radius R. A small ball of mass m is released from rest at the end A of the tunnel. Acceleration due to gravity at surface of the planet is g. Time taken by the ball to reach the end B is

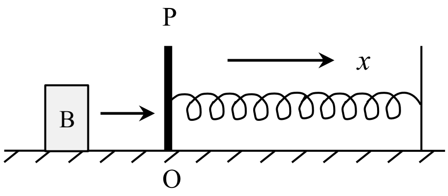
    (a) $\pi\sqrt{\frac{R}{g}}$ (b) $2\sqrt{\frac{\ell}{g}}$
    (c) $\frac{\pi}{2}\sqrt{\frac{2R}{g}}$ (d) $2\pi\sqrt{\frac{R}{g}}$



14. When the speaker S_1 is switched ON, the sound intensity at a point P in a room is 80 dB. But when the speaker S_2 is switched ON (S_1 is switched OFF), the sound intensity at the same point P in the room is 85 dB. The sound intensity level (in dB) at the same point P in the room, if the two speakers S_1 and S_2 are simultaneously switched ON, is (consider the speakers to be incoherent)

(a) 165 dB (b) 86.2 dB (c) 87.8 dB (d) 88.6 dB

15. A block B of mass 0.5 kg moving, on a horizontal frictionless table at 2.0 ms^{-1}, collides with a massless pan P (at origin O) and sticks to it. The pan is connected at the end of a horizontal un-stretched (relaxed) spring of force constant K = 32 Nm^{-1} as shown in figure. After the block collides, the displacement $x(t)$ of the block as a function of time t is given by



(a) $0.25 \cos 8t\ m$ (b) $0.25 \sin 8t\ m$ (c) $2.50 \sin \frac{t}{8}\ m$ (d) $0.50 \sin \frac{\pi}{4}t\ m$

16. Which of the following functions does not represent a traveling wave

(a) $y = A \sin^2\left[\pi\left(t - \frac{x}{v}\right)\right]$ (b) $y = A e^{-\alpha t} \cos(kx - \omega t)$

(c) $y = A \sin\left[(kx)^2 - (\omega t)^2\right]$ (d) $y = A \cos\left[(kx - \omega t)^2\right]$

17. Two Carnot heat engines are connected in series such that the sink of the first engine is heat source of the second. Efficiency of the engines are η_1 and η_2 respectively. Net efficiency η of the combination is given by

(a) $\eta = \eta_1 + \eta_2$ (b) $\eta = \frac{\eta_1 \eta_2}{\eta_1 + \eta_2}$

(c) $\eta = \eta_1 + \eta_2(1 - \eta_1)$ (d) $\eta = \eta_1 - \eta_2(1 - \eta_1)$

18. An air bubble of radius 2 mm at a depth 12 m below the surface of water at temperature of 8 °C, rises to the surface where the temperature is 16 °C. Neglecting the effect of Surface Tension, the radius of the bubble at the surface is estimated to be

(a) 2.56 mm (b) 2.61 mm (c) 2.86 mm (d) 4.45 mm

19. Two soap bubbles of radii a and b coalesce to form a single bubble of radius c under isothermal conditions. If the external pressure is p_A, then the Surface Tension (T) of the soap solution is

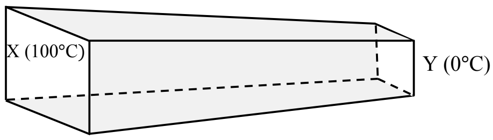
(a) $\frac{P_A}{4}\frac{(c^3 - a^3 - b^3)}{(a^2 + b^2 - c^2)}$ (b) $\frac{P_A}{2}\frac{(a^3 + b^3 - c^3)}{(c^2 - a^2 - b^2)}$

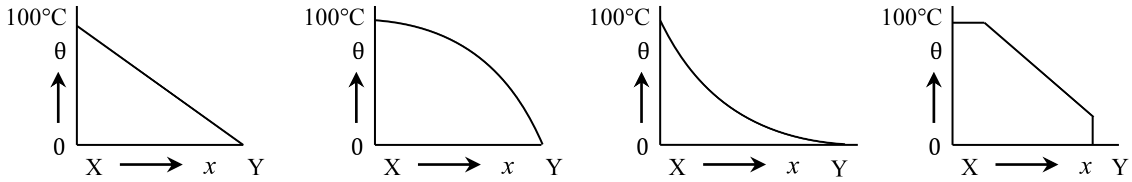
(c) $\frac{P_A}{2}\frac{(a^2 + b^2 - c^2)}{(c^3 - a^3 - b^3)}$ (d) $\frac{P_A}{4}\frac{(c^2 - a^2 - b^2)}{(a + b - c)}$

20. An open-end organ pipe 30 cm in length and a closed-end organ pipe 23 cm in length, both of equal diameter, are each sounding their first overtone and both are in unison at 1100 Hz. The speed of sound in air, is estimated to be nearly

(a) 324 ms^{-1} (b) 332 ms^{-1} (c) 340 ms^{-1} (d) 352 ms^{-1}

21. The figure shows a lagged bar XY of non-uniform cross section. One end X of the bar is maintained at 100 °C and the other end Y at 0 °C. The variation of temperature along its length from X to Y in steady state is best represented by the curve.





(a) (b) (c) (d)

22. An ideal gas (n moles) is initially at pressure P and temperature T. It is cooled isochorically to a pressure $\frac{P}{4}$. The gas is then expanded at a constant pressure so as to attain back its initial temperature T. Work done by gas during the entire process is

(a) $\frac{5}{4}nRT$ (b) $\frac{3}{4}nRT$ (c) $\frac{1}{4}nRT$ (d) Zero

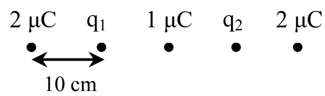
23. Assuming the Sun to be a spherical body (radius R_S) of surface temperature T, the total radiation power received by Earth (radius R_E) at a distance r from Sun is

(a) $\frac{\sigma \pi R_E^2 R_S^2 T^4}{r^2}$ (b) $\frac{\sigma 4\pi R_E^2 R_S^2 T^4}{r^2}$ (c) $\frac{\sigma \pi R_E^2 R_S^2 T^4}{4r^2}$ (d) $\frac{\sigma R_E^2 R_S^2 T^4}{4\pi r^2}$

24. The figure shows five point-charges on a straight line. Separation between successive charges is 10 cm. For what values of q_1 and q_2 would the net force on each of the other three charges be zero?

(a) $q_1 = q_2 = -\frac{27}{80}\mu C$ (b) $q_1 = q_2 = \frac{27}{40}\mu C$

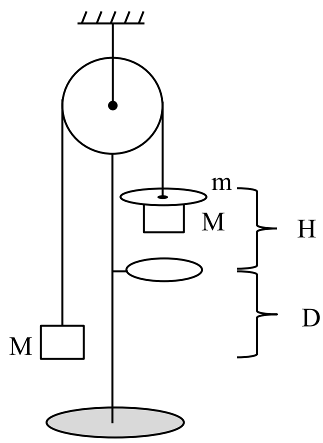
(c) $q_1 = \frac{27}{80}\mu C$ $q_2 = -\frac{27}{80}\mu C$ (d) $q_1 = q_2 = -\frac{27}{40}\mu C$



25. Two equal blocks, each of mass M, hang on either side of a frictionless light pulley with a light string. A rider of mass m is placed on one of the blocks (as shown). When the system is released, the block with rider descends a distance H till the rider is caught by a ring that allows the block to pass through. The system moves a further distance D taking time t. In such a situation, the acceleration due to gravity is

(a) $g = \frac{(2M+m)D^2}{2mHt^2}$ (b) $g = \frac{(M+m)D^2}{2mHt^2}$

(c) $g = \frac{(2M+m)D}{mHt^2}$ (d) $g = \frac{(M+2m)D^2}{mHt^2}$



26. A very small electric dipole of dipole moment $\vec{p}$ lies along the x axis $\left(i.e\ \vec{p} = p\hat{i}\right)$ in a non-uniform electric field $\vec{E} = \frac{c}{x}\hat{i}$ (where c is a constant). The force on the dipole is

(a) $\frac{cp}{x^2}\hat{i}$ (b) $-\frac{c\vec{p}}{x^2}\hat{i}$ (c) $\frac{cp}{x}\hat{i}$ (d) zero

27. A conducting thick spherical shell of radii a and b (b > a) has been charged with uniform surface charge density $-\sigma\ \ C/m^2$ on the inner and $+\sigma\ \ C/m^2$ on the outer surfaces. Then

(a) the net charge on the spherical shell is zero.

(b) the radial electric field outside the shell is $E = \frac{\sigma b^2}{\varepsilon_0 r^2}$

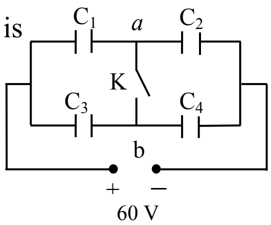
(c) a radial electric field $E = \frac{\sigma\left(b^2 - a^2\right)}{\varepsilon_0 r^2}$ exists outside the shell.

(d) there is a net electric charge in the cavity (i.e. in region r < a) equal to $4\pi\sigma\left(b^2 - a^2\right)$

28. A spherical conductor is charged up to a potential of 450 V. The potential outside, at a distance 15 cm from the surface, is 300 V. Then

(a) the potential at 15 cm from the center is 900 V
(b) the charge on the conductor is 1.5 nC
(c) the electric field just outside the surface is 150 N/C
(d) the total electrical energy of the conductor is $U = 3.375\ \ \mu J$

29. Capacitors $C_1 = 3\mu F$, $C_2 = 6\mu F$, $C_3 = 4\mu F$ and $C_4 = 1\mu F$ are connected in a circuit as shown to a battery of 60 V. Now if key K is closed, the charge that will flow through K is

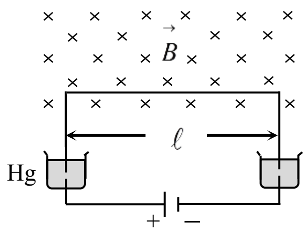


(a) $90\mu C$ from b to a (b) $60\mu C$ from b to a
(c) $30\mu C$ from a to b (d) $150\mu C$ from b to a

30. The electrical conductivity of a sample of semiconductor is found to increase when the electromagnetic radiation of wave length just shorter than 2480 nm is incident normally on its surface. The band gap of the semiconductor is

(a) 1.96 eV (b) 1.12 eV (c) 0.50 eV (d) 0.29 eV

31. A U-shaped conducting wire of mass $m = 10\,g$, having length of its horizontal section as $\ell = 20\,cm$, is free to move vertically up and down. The two ends of the wire are immersed in mercury for proper electrical contact. The wire is in a homogeneous field of magnetic induction $B = 0.1\ \ T$ as shown. The wire jumps up to a height $h = 3\,m$ when a charge q, in the form of a current pulse, is sent through the wire. Considering that the duration of the current pulse is very small compared to the time of flight, the charge q passed through the wire is estimated to be nearly

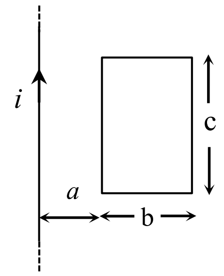


(a) 6.85 μC (b) 9.80 μC
(c) 2.84 C (d) 3.84 C

32. A target of ^{7}Li is bombarded with a proton beam of current 10^{-4} ampere for 1 hour to produce ^{7}Be of activity 1.8×10^8 disintegrations per second. Assuming that bombarding of 1000 protons produces one ^{7}Be radioactive nucleus, the half-life of ^{7}Be is estimated to be approximately

    (a) 6887 hour (b) 4332 hour (c) 2407 hour (d) 2195 hour

33. A long straight wire carrying a current $i = 10\,A$ and a rectangular metallic loop of dimensions b × c lie in the same plane as shown in the figure. The parameters are $a = 10\ cm$, $b = 30\ cm$ and $c = 50\ cm$. The mutual inductance of the system is nearly

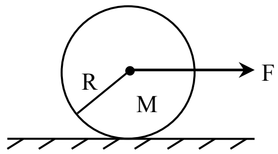


    (a) 69 nH (b) 71 nH
    (c) 139 nH (d) 281 nH

34. Impedance of a given series LCR circuit, fed with alternating current, is the same for two frequencies f_1 and f_2. The resonance frequency f_R of the circuit is

    (a) $\dfrac{f_1 + f_2}{2}$ (b) $\dfrac{2 f_1 f_2}{f_1 + f_2}$ (c) $\sqrt{f_1 f_2}$ (d) $\sqrt{f_1^2 + f_2^2}$

35. A lawn roller is a solid cylinder of mass M and radius R. As shown in the figure, it is pulled at its center by a horizontal force F and rolls without slipping on a horizontal surface. Then the



    (a) acceleration of the cylinder is $\dfrac{2F}{M}$

    (b) force of friction acting on the cylinder is $\dfrac{2F}{3M}$

    (c) coefficient of friction needed to prevent slipping is at least $\dfrac{F}{3Mg}$

    (d) minimum coefficient of friction to prevent slipping is $\dfrac{2F}{3Mg}$

36. A hydrogen atom (M_H = 1.67×10^{-27} kg), initially at rest, emits a photon and goes from the excited state $n = 5$ to the ground state. The recoil speed of the atom is nearly

    (a) $4.2\ ms^{-1}$ (b) $4 \times 10^{-4}\ ms^{-1}$ (c) $2 \times 10^{-2}\ ms^{-1}$ (d) $8 \times 10^2\ ms^{-1}$

37. Two nuclides A and B are isotopes. The nuclides B and C are isobars. All the three nuclides A, B and C are radioactive. You may then conclude that

    (a) the nuclides A, B and C must belong to the same element
    (b) the nuclides A, B and C may belong to the same element
    (c) it is possible that A may change to B through a radioactive decay process
    (d) it is possible that B may change to C through a radioactive decay process

38. Numerical aperture of an optical fibre is a measure of

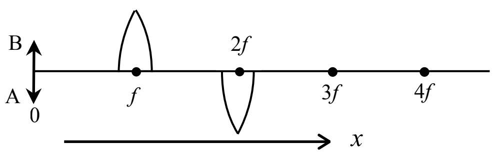
    (a) the attenuation of light through it (b) its resolving power
    (c) the pulse dispersion through it (d) its light gathering power

39. Heavy stable nuclei have more neutrons than protons. This is because of the fact that
   (a) neutrons are heavier than protons
   (b) the electrostatic forces between protons are repulsive
   (c) neutrons decay into protons through beta decay
   (d) the nuclear forces between neutrons are weaker than those between protons

40. An equi-concave lens of radii of curvature of the two surfaces numerically equal to 7 cm and refractive index $\mu = 1.5$ has a small silver dot on the rear surface. As a result of this, a ray of light incident parallel to the principal axis gets reflected from its rear surface and then reflected also from the inner front surface. The ray after the second reflection emerges out of the thin lens and appears to focus at a point P on the principal axis. The point P lies
   (a) 1 cm before the lens (b) 2 cm before the lens
   (c) 1 cm beyond the lens (d) at none of these

41. Light emerges out uniformly from a point source placed at the focus of a concave mirror to give out a spherical wave front. As a result of reflection of the paraxial rays from the concave mirror, according to Huygen's theory the reflected light is in the form of a
   (a) spherical wave front with centre at the focus, and radius equal to the radius of curvature of the mirror
   (b) spherical wave front with centre at the focus, and radius equal to the focal length of the mirror
   (c) cylindrical wave front with its axis coinciding with the principal axis of the mirror.
   (d) plane wave front perpendicular to the reflected beam

42. An equi-convex lens of focal length 'f' is cut along a diameter, in two halves (pieces). The two identical pieces of the lens are now arranged as shown in the figure on a common axis at a separation f between the two. The image of an object AB placed at $x = 0$ **cannot** be formed at the distance $x = \xi$ from the object along the axis, for the value of ξ as



   (a) $\xi = 2f$ (b) $\xi = 3f$ (c) $\xi = 4f$ (d) $\xi = \infty$

43. During the processes of annihilation of a stationary electron of mass m_0 with a stationary positron of equal mass, a radiation is emitted. The wavelength of the resulting radiation is
   (a) $\frac{h}{m_0 c}$ (b) $\frac{2h}{m_0 c}$ (c) $\frac{m_0}{hc}$ (d) $\frac{m_0 c}{h}$

44. The convex surface of a concavo-convex lens of refractive index 1.5 and radii of curvature R_1 = 20 cm and R_2 = 40 cm has been silvered so as to make it reflecting. The distance of a luminous object from the reflecting system when placed in front of it on its principal axis, so that the image coincides with the object is
   (a) 40 cm (b) 32 cm (c) 16 cm (d) 8 cm

45. A direct vision spectroscope has been designed to obtain dispersion without deviation by arranging alternate inverted thin prisms of crown glass (refractive index $\mu_1 = \sqrt{2}$) and flint glass $(\mu_2 = \sqrt{3})$ with refracting angle $\theta_{flint} = 3^\circ$. The refracting angle θ_{crown} of the crown glass prism is

(a) 3.0° (b) 4.5° (c) 5.3° (d) 6.0°

46. Continuous and Characteristic X – rays are produced when electron beam accelerated by a high potential difference of V volt (say) is made to hit the metallic target such as Molybdenum in a modern Coolidge tube. Let $\lambda_{\min}$ be the smallest possible wavelength of continuous X – rays and $\lambda_{L\alpha}$ be the maximum wavelength of the characteristic X- rays. Then

(a) $\lambda_{L\alpha}$ increases with increase in V (b) $\lambda_{L\alpha}$ decreases with increase in V

(c) $\lambda_{\min}$ increases with increase in V (d) $\lambda_{\min}$ decreases with increase in V

47. While performing an experiment for determining the focal length of a concave mirror by u-v method, a student recorded the given sets of the positions (in cm) of the object and the corresponding image on the bench as (12, 51), (18, 54), (30, 50), (48, 34), (42, 42) and (78, 98). She used an optical bench of length 1.5 m and the mirror is fixed at the 90 cm mark on the bench. The maximum acceptable error in the location of the image is 0.2 cm. The reading (observation) that cannot be obtained from experimental measurement and has been incorrectly recorded, for a mirror of focal length = 24 cm, is

(a) (18, 54) (b) (30, 50) (c) (48, 34) (d) (78, 98)

48. A parallel beam, of 6.0 mW radiation of wavelength $200\,nm$ and of area of cross-section $1.0\ \text{mm}^2$, falls normally on a plane metallic surface. If the radiations are completely reflected, the pressure exerted by the radiations on the metallic surface is estimated to be

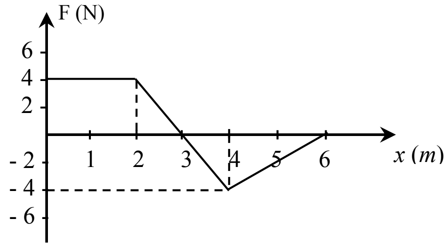
(a) $1\times10^{5}\ Pa$ (b) $2\times10^{5}\ Pa$ (c) $2\times10^{-5}\ Pa$ (d) $4\times10^{-5}\ Pa$

A – 2

ANY NUMBER OF OPTIONS (4, 3, 2 or 1) MAY BE CORRECT

MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED AND NO INCORRECT.

49. The force F(x) acting on a body of mass m changes with position x (in meter) as shown. It is given that the potential energy U(x) = 0 at x = 0
Choose correct option(s).
   (a) $U(x) = 0$ at $x = 0$, $x = 3$ and $x = 6$
   (b) $U(x) = 2x^2 - 12x$ for $2 \le x \le 4$
   (c) $U(x) = -x^2 + 12x - 40$ for $4 \le x \le 6$
   (d) At $x = 3$, $U(x) = -10\,J$



50. A deuteron of mass M moving at speed v collides elastically with an α - particle of mass 2M, initially at rest. The deuteron is scattered through 90° from initial direction of its motion with speed V_d while the α - particle is scattered with speed V_α at an angle θ from the initial direction of motion of deuteron. Then
   (a) $\theta = 30°$
   (b) $V_\alpha = \frac{v}{\sqrt{3}}$
   (c) $V_d = \frac{v}{\sqrt{3}}$
   (d) a fraction $\frac{2}{3}$ of energy of deuteron is transferred to α particle

51. Two plane progressive waves travelling on a string as
$$y_1 = 2.5\times10^{-3}\ \sin(30x - 420t)$$
$$y_2 = 2.5\times10^{-3}\ \sin(30x + 420t)$$
superimpose to produce a standing wave. The variables x and y are in meter and t is in second. Then
   (a) the equation of resultant standing wave is $y = 5\times10^{-3}\cos(30x)\sin(420t)$
   (b) the equation of resultant standing wave is $y = 2.5\times10^{-3}\sin(30x)\cos(420t)$
   (c) the antinode closest to $x = 0.25\ m$ is at $x = 0.262\ m$
   (d) the amplitude of oscillation of particle at $x = 0.17\ m$ is $4.63\ mm$

52. Two moles of nitrogen in a container, of negligible thermal capacity, are initially at 17 °C. The gas is compressed adiabatically from an initial volume of 120 liter to 80 liter. The correct option(s) is/are
   (a) Initial pressure of the gas is nearly $40.2\ kPa$
   (b) Final temperature of the gas is nearly 68 °C
   (c) Work done by the gas is $2.12\ kJ$
   (d) The internal energy of the gas increases by $2.12\ kJ$

53. A small dipole is placed at the origin with its dipole moment $\vec{P} = p\,\hat{i}$ oriented along x axis. E and V, are respectively, the Electric field and potential at point A(x, y). The observations at the Point A(x, y) which is at a large distance r from the origin, show that

(a) $E_x = \dfrac{1}{4\pi\varepsilon_0}\dfrac{p\left(2x^2 - y^2\right)}{r^5}$ (b) $E_x = \dfrac{1}{4\pi\varepsilon_0}\dfrac{p\left(x^2 - 2y^2\right)}{r^5}$

(c) $E_y = \dfrac{1}{4\pi\varepsilon_0}\dfrac{3\,p\,x\,y}{r^5}$ (d) $V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{\vec{P}.\vec{r}}{r^3}$

54. Two equal positive charges +Q each lie on y axis at (0, a) and (0, – a). The electric field strength E at a point (x, 0) satisfies:

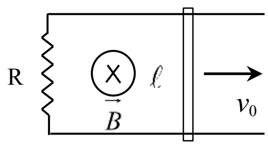
(a) $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{2Qa}{(x^2 + a^2)^{3/2}}$

(b) for large values of x $(i.e\ \ x >> a)$, the electric field $E \propto \dfrac{1}{x^2}$

(c) for $x \geq 0$, E is maximum at $x = \dfrac{a}{\sqrt{2}}$

(d) for $x \geq 0$, E is maximum at x = 0 and is equal to $\dfrac{1}{4\pi\varepsilon_0}\dfrac{2Q}{a^2}$

55. A metal rod of mass m and length ℓ slides on frictionless parallel metal rails of negligible resistance, A resistance R is connected between the rails at their ends as shown in the figure. A uniform magnetic field B is directed into the plane of paper perpendicular to the plane of rails throughout the space. The rod is given an initial velocity v_0 (towards right). No other force acts on the rod. Then



(a) $v(t) = v_0 e^{\frac{-B\ell t}{mR}}$

(b) the rod stops after traveling a distance $x = \dfrac{m\,v_0\,R}{B^2\,\ell^2}$

(c) the total energy dissipated in resistance is $\dfrac{1}{4}mv_0^2$ i.e. half of the initial kinetic energy

(d) the total charge that flows in the circuit is $q = \dfrac{mv_0}{B\ell}$

56. The magnetic field $\vec{B} = 2\times10^{-5}\sin\left\{\pi\left(0.5\times10^3 x + 1.5\times10^{11}t\right)\right\}\hat{j}\ T$ represents a plane electromagnetic wave travelling in space with x in meter and t in second. The correct statement(s) are

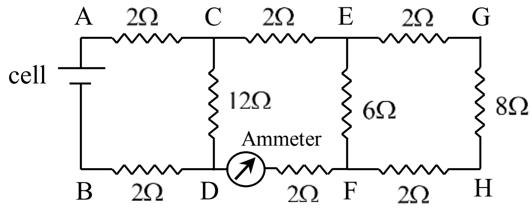
(a) The wave length of the wave is 4.0 mm and its frequency is 75 GHz

(b) The energy density associated with the wave is nearly $=316\ \mu J/m^3$

(c) The electric field vector is $\vec{E} = -6000\ \sin\left[\pi\left(0.5\times10^3 x - 1.5\times10^{11}t\right)\right]\hat{k}\ Vm^{-1}$

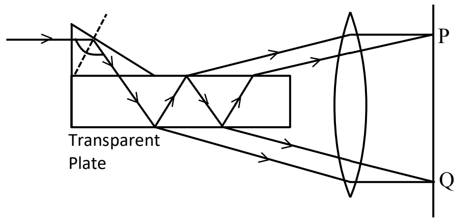
(d) The electric field vector is $\vec{E} = 6000\ \sin\left[\pi\left(0.5\times10^3 x + 1.5\times10^{11}t\right)\right]\hat{k}\ Vm^{-1}$

57. In the circuit shown, the current in the 8Ω resistance across G and H is $i = 0.5$ ampere. The ammeter is ideal. The internal resistance of the cell is $0.8\ \Omega$. Choose correct option(s).



(a) Reading of the ammeter is 1.5 ampere
(b) Potential difference across A and H is 13 V
(c) Potential difference across C and F is 9 V
(d) The emf of the cell is 24 V

58. In an experiment with Lummer Gehrecke plate, the two coherent beams of light, caused by multiple reflections inside the transparent plate of refractive index $\mu = 1.54$, reach the points P and Q on the screen. The net path difference between the two beams reaching either at P or Q is $\Delta x = 5000\ nm$. Which of the wavelengths in the visible range ($\lambda = 390\,nm$ to $\lambda = 780\,nm$) is/are most likely to produce a constructive interference (a maximum) at the point P as well as at Q on the screen**?**



(a) 416.67 nm (b) 555.56 nm (c) 625.00 nm (d) 666.70 nm

59. Two identical transparent solid cylinders, each of radius 10 cm and refractive index $\mu = \sqrt{3}$, lie horizontally parallel to each other on a horizontal plane mirror with a separation x between their horizontal axes. A ray of light is incident horizontally on the cylinder A at a height h above the plane mirror so as to emerge from this cylinder at a height $h_1 = 0.1\ m$ above the plane mirror. The ray emerging out from the first cylinder A is reflected from the horizontal plane mirror to enter the second parallel cylinder B at a height h_2 and then this ray emerges out of the second cylinder, parallel and in-line with the original incident ray. The correct statement(s) is/are:
(a) the height h above the plane mirror is $h = 18.7\ cm$
(b) the ray enters the second cylinder B at a height $h_2 = 0.1\ m$
(c) the separation between the axes of the two cylinders **A** and **B** is $x = 31.54\ cm$
(d) the angle of incidence on the plane mirror midway between the two cylinders is $\theta = 30^\circ$

60. In the working of a $p-n$ junction
(a) diffusion current dominates when the junction is forward biased
(b) drift current dominates when the junction is reverse biased
(c) depletion region width decreases with increase in forward bias voltage.
(d) the electric field in the depletion region depends on the number of ionized dopants rather than the dopant density.

Rough work

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS

NSEP - 2023

FINAL ANSWER KEY NSEP - 2023

QUESTION	PAPER CODE 61	PAPER CODE 62	PAPER CODE 63	PAPER CODE 64
1	c	b	c	b
2	b	d	c	a
3	c	a	c	d
4	d	a	c	a
5	a	b	a	a
6	c	b	d	c
7	b	b	d	c
8	d	a	b	b
9	a	b	a	c
10	a	c	d	d
11	b	c	a	a
12	b	b	a	c
13	a	a	c	b
14	b	d	c	d
15	b	b	b	a
16	c	b	c	a
17	c	a	d	b
18	b	a	a	b
19	a	a	c	a
20	d	a	b	b
21	b	b	d	b
22	b	b	a	c
23	a	d	a	c
24	a	d	b	b
25	a	c	b	a
26	b	c	a	d
27	b	c	b	b
28	d	c	b	b
29	a	c	c	a
30	c	a	c	a

QUESTION	PAPER CODE 61	PAPER CODE 62	PAPER CODE 63	PAPER CODE 64
31	d	d	b	a
32	c	d	a	b
33	c	b	d	b
34	c	a	b	d
35	c	d	b	a
36	a	a	a	c
37	d	a	a	d
38	d	c	a	c
39	b	c	b	c
40	a	b	b	c
41	d	c	d	c
42	a	d	a	a
43	a	a	c	d
44	c	c	d	d
45	c	c	c	c
46	d	d	d	d
47	d	d	d	d
48	d	d	d	d
49	c, d	a, b, c, d	b, d	a, c, d
50	a, b, c, d	a, b, c	a, d	b, c
51	c, d	a, b, c, d	c, d	b, d
52	a, b, d	a, b, c **or** a, b, c, d	a, b, c, d	a, d
53	a, c, d	c, d	c, d	c, d
54	b, c	a, b, c, d	a, b, d	a, b, c, d
55	b, d	c, d	a, c, d	c, d
56	a, d	a, b, d	b, c	a, b, d
57	a, b, c, d	a, c, d	a, b, c, d	a, b, c, d
58	a, b, c	b, c	a, b, c	a, b, c
59	a, b, c, d	b, d	a, b, c, d	a, b, c, d
60	a, b, c **or** a, b, c, d	a, d	a, b, c **or** a, b, c, d	a, b, c **or** a, b, c, d

Final Answer Keys NSEP - 2019; held on November 24, 2019

	Code: 61	Code: 62	Code: 63	Code: 64		Code: 61	Code: 62	Code: 63	Code: 64
Question Number	**Keys**	**Keys**	**Keys**	**Keys**	**Question Number**	**Keys**	**Keys**	**Keys**	**Keys**
1	d	b	a	b	**41**	b	d	a	d
2	b	d	b	d	**42**	a	c	d	d
3	c	c	a	c	**43**	d	a	d	c
4	d	Droped	d	Droped	**44**	d	b	c	c
5	d	b	a	b	**45**	c	a	c	d
6	d	a	d	d	**46**	c	d	d	d
7	d	d	b	d	**47**	d	a	b	c
8	b	a	d	d	**48**	d	a	b	c
9	d	b	a	c	**49**	d	b	b	c
10	c	c	a	a	**50**	d	c	c	d
11	Droped	c	d	c	**51**	c	b	d	a
12	b	c	c	a	**52**	a	a	d	a
13	d	d	a	b	**53**	c	d	a	d
14	b	c	b	c	**54**	b	d	d	a
15	d	c	c	b	**55**	b	d	d	b
16	a	c	b	a	**56**	b	c	b	c
17	a	d	a	a	**57**	c	a	d	c
18	d	a	d	b	**58**	d	c	c	c
19	c	d	d	a	**59**	d	d	Droped	d
20	a	d	d	d	**60**	a	d	b	d
21	d	c	c	a	**61**	a & d	a,b,c &d	a & d	a & d
22	a	c	a	d	**62**	c & d	a,c & d	c & d	c & d
23	b	d	c	b	**63**	a,c & d	a,b,c &d	a,c & d	a,c & d
24	c	b	d	d	**64**	a,b & c	a,b,c & d	a,b & c	a,b & c
25	c	b	b	a	**65**	a,b,c & d	b & d	a,b,c & d	a,b,c & d
26	c	b	c	a	**66**	a,c, & d	b	a,c, & d	a,c, & d
27	a	c	d	d	**67**	a,b,c & d	a &d	a,b,c & d	a,b,c & d
28	b	d	d	c	**68**	a,b,c & d	c & d	a,b,c & d	a,b,c & d
29	a	d	a	d	**69**	b & d	a,c & d	b & d	b & d
30	d	a	d	b	**70**	b	a,b & c	b	b
31	a	d	a	c					
32	d	b	b	d					
33	c	c	c	d					
34	c	d	c	b					
35	c	d	c	b					
36	d	d	d	b					
37	a	b	c	c					
38	a	d	c	d					
39	b	a	c	d					
40	c	a	d	a					

IOQP - 61

Time: 9:00 AM to 10:00 AM
Question Paper Code: 61

Student's Roll No:														

Write the question paper code mentioned above on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch, and iPad during examination is STRICTLY PROHIBITED.
2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.

   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE** or **BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **fourteen-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in Indian Olympiad Qualifier in Physics 2020-21 (Part I).
6. Question paper has two parts. In part A1 (Q. No.1 to 24) each question has four alternatives, out of which only one is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   Q.No. 12 a ● c d

   In part A2 (Q. No. 25 to 32) each question has four alternatives out of which any number of alternative(s) (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternative(s) and fill the appropriate bubble(s), as shown

   Q.No. 30 a ● c ●
7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked and no incorrect. No negative marks in this part.
8. Rough work should be done only in the space provided. There are **08** printed pages in this paper.
9. Use of **non- programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper and candidate's copy of OMR for your reference

    Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

    OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

    DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued) :

You may read the following instructions after submitting the answer sheet.

12. Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iaptexam.in on the specified format till February 12, 2021.

13. The answers/solutions to this question paper will be available on the website: www.iapt.org.in by February 13, 2021.

14. CERTIFICATES and AWARDS:

Following certificates are awarded by IAPT to students, successful in the Indian Olympiad Qualifier in Physics 2020-21 (Part I)

(i) "CENTRE TOP 10 %"

(ii) "STATE TOP 1 %"

(iii) "NATIONAL TOP 1 %"

(iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC-2021 at HBCSE Mumbai

15. All these certificates (except gold medal) will be downloadable from IAPT website : www.iapt.org.in after March 15, 2020-21.

16. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: www.iapt.org.in by **February 25, 2021. See the Minimum Admissible score Clause** on the Student's brochure on the web.

17. List of Students eligible for evaluation of IOQP 2020-21 (Part II) shall be displayed on www.iapt.org.in by March 1, 2021.

Physical constants you may need….

Mass of electron $m_e = 9.10\times10^{-31}$kg	Magnitude of charge on electron $e = 1.60\times10^{-19}$ C
Mass of proton $m_p = 1.67\times10^{-27}$kg	Permittivity of free space $\varepsilon_0 = 8.85\times10^{-12}$ $C^2N^{-1}m^{-2}$
Acceleration due to gravity $g = 9.8$ ms^{-2}	Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ Hm^{-1}
Universal gravitational constant $G = 6.67\times10^{-11}$ Nm^2Kg^{-2}	Planck's constant $h = 6.625\times10^{-34}$ Js
Universal gas constant $R = 8.31$ $Jmol^{-1}K^{-1}$	Faraday constant = 96,500 $Cmol^{-1}$
Boltzmann constant $k = 1.38\times10^{-23}$ JK^{-1}	Rydberg constant $R = 1.097\times10^{7}$ m^{-1}
Stefan's constant $\sigma = 5.67\times10^{-8}$ $Wm^{-2}K^{-4}$	Speed of light in free space $c = 3\times10^{8}$ ms^{-1}
Avogadro's constant $N_A = 6.023\times10^{23}$ mol^{-1}	

Question Paper Code: 61

Time: 60 Minute **Max. Marks: 120**

Attempt All Thirty Two Questions

A - 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

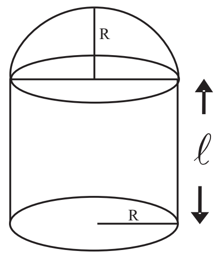
1. If speed of light c, Planck's constant h and gravitational constant G are chosen as fundamental quantities, dimensions of time in this system of units is

(a) $ch^{3/2}G^{-3/2}$ (b) $c^{-2}G^{1/2}h$ (c) $c^{2}G^{1/2}h^{5/2}$ (d) $c^{-5/2}G^{1/2}h^{1/2}$

2. A solid hemisphere is cemented on the flat surface of a solid cylinder of same radius R and same material. The composite body is rotating about the axis of the cylinder of length ℓ with angular speed ω. The radius of gyration K is

(a) $R\sqrt{\frac{2}{5}\left(\frac{15R+8\ell}{3R+2\ell}\right)}$ (b) $R\sqrt{\frac{1}{10}\left(\frac{15\ell+8R}{3\ell+2R}\right)}$

(c) $R\sqrt{\frac{3}{10}\left(\frac{15R+8\ell}{3R+2\ell}\right)}$ (d) $R\sqrt{\frac{1}{10}\left(\frac{3\ell+2R}{15\ell+8R}\right)}$



3. The shortest period of rotation of a planet (considered to be a sphere of uniform density ρ) about its own axis, such that any mass m kept on its equator is just to fly off the surface, is

(a) $T=\sqrt{\frac{5\pi}{\rho G}}$ (b) $T=\sqrt{\frac{\pi}{3\rho G}}$ (c) $T=\sqrt{\frac{3\pi}{\rho G}}$ (d) $T=\sqrt{\frac{5\pi}{3\rho G}}$

4. A body of mass 10 kg at rest explodes into two fragments of masses 3 kg and 7 kg. If the total kinetic energy of two pieces after explosion is 1680 J, the magnitude of their relative velocity in m/s after explosion is:

(a) 40 (b) 50 (c) 70 (d) 80

5. A shot is fired at an angle α to the horizontal up a hill (Considered to be a long straight incline plane) of inclination β to the horizontal. It will strike the hill horizontally if

(a) $\tan\alpha = 2\tan\beta$ (b) $\sin\alpha = \sin 2\beta$ (c) $\sin\alpha = 2\sin\beta$ (d) $\tan\alpha = 4\tan\beta$

6. A particle is executing Simple Harmonic Motion of time period $T = 4\pi^2$ in a straight line. Starting from rest, it travels a distance 'a' in the first second and distance 'b' in the next second travelling in the same direction. The amplitude of SHM is

(a) $\frac{2a^2}{3a-b}$ (b) $\frac{3a^2}{3a-2b}$ (c) $\frac{2a^2}{2a-b}$ (d) none of these

7. The kinetic energy of a particle moving along a circle of radius R depends upon the distance covered 's' as $KE = as^2$ where a is a constant. The magnitude of the force acting on the particle as a function of 's' is

(a) $\frac{2as^2}{R}$ (b) $\frac{2as^2}{m}$ (c) 2as (d) $2as\sqrt{1+\left(\frac{s}{R}\right)^2}$

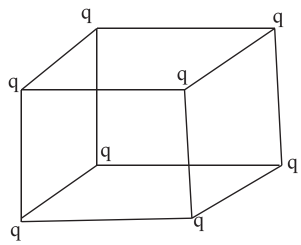
8. The flow of water in a horizontal pipe is stream line flow. Along the pipe, at a point, where cross - sectional area is 10 cm^2, the velocity of water flow is 1.00 ms^{-1} and the pressure is 2000 Pa. The pressure of water at another point where cross - sectional area is 5 cm^2 is

(a) 2000 Pa (b) 1500 Pa (c) 3500 Pa (d) 500 Pa

9. Three containers A, B and C are filled with water at different temperature. When 1 litre of water from A is mixed with 2 litre of water from B, the resulting temperature of mixture is 52^0 C. When 1 litre of water from B is mixed with 2 litre of water from C, the resulting temperature of mixture is 40^0 C. Similarly when 1 litre of water from C is mixed with 2 litre of water from A, the resulting temperature of mixture is 34^0 C. Temperature of mixture when one litre of water from each container is mixed (neglect the water equivalent of container) is

(a) 40^0 C (b) 42^0 C (c) 38^0 C (d) 45^0 C

10. Point charge q is kept at each corner of a cube of edge length ℓ. The resultant force of repulsion on any one of the charges due to all others is expressed as



(a) $\frac{\left(1+\frac{1}{2\sqrt{2}}+\frac{1}{3\sqrt{3}}\right)q^2}{\pi\varepsilon_0 \ell^2}$ (b) $\frac{\left(\frac{1}{2\sqrt{2}}-1+\frac{1}{3\sqrt{3}}\right)q^2}{\pi\varepsilon_0 \ell^2}$

(c) $\frac{(1-0.1775)q^2}{\pi\varepsilon_0 \ell^2}$ (d) none of these

11. In an experiment with potentiometer, the balancing length is 250 cm for a cell. When the cell is shunted by a resistance of 7.5 Ω, balancing point is shifted by 25 cm. If the cell is shunted by a resistance of 20 Ω, the balancing length will be nearly

(a) 240 cm (b) 236 cm (c) 232 cm (d) 230 cm

12. One mole of a gas with $\gamma = \frac{5}{3}$ is mixed with two moles of another non-interacting gas with $\gamma = \frac{7}{5}$ The ratio of specific heats $\gamma = \frac{C_P}{C_V}$ of mixture is approximately

(a) 1.50 (b) 1.46 (c) 1.49 (d) 1.53

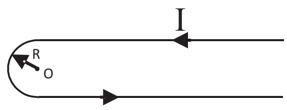
13. An ideal gas is expanding such that PT^3 = constant. The coefficient of volume expansion of the gas is

(a) $\frac{1}{T}$ (b) $\frac{2}{T}$ (c) $\frac{3}{T}$ (d) $\frac{4}{T}$

14. What is the magnetic induction B at the centre O of the semicircular arc if a current carrying wire has shape of an hair pin as shown in figure? The radius of the curved part of the wire is R, the linear parts are assumed to be very long.

(a) $B = \frac{\mu_0 I}{4\pi R}(2+\pi)$ (b) $B = \frac{\mu_0 I}{4R}(2+\pi)$

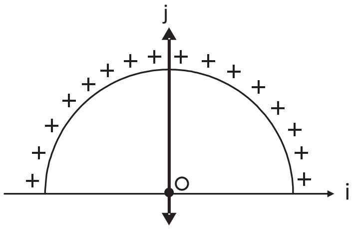
(c) $B = \frac{3\mu_0 I}{4R}(2+\pi)$ (d) $B = \frac{\mu_0}{4\pi}\frac{2I}{R}$



15. A thin semi-circular metal ring of radius R has a positive charge q distributed uniformly over its curved length. The resultant electric field $\vec{E}$ at the center O is

(a) $-\hat{j}\frac{q}{2\pi^2\varepsilon_0 R^2}$ (b) $+\hat{j}\frac{q}{2\pi^2\varepsilon_0 R^2}$

(c) $+\hat{j}\frac{q}{4\pi^2\varepsilon_0 R^2}$ (d) $-\hat{j}\frac{q}{4\pi^2\varepsilon_0 R^2}$



16. An Alternating Current is expressed as $i = i_1 \cos\omega t + i_2 \sin\omega t$. The RMS value of current is

(a) $\sqrt{\frac{(i_1+i_2)^2}{2}}$ (b) $\sqrt{\frac{i_1 i_2}{2}}$ (c) $\sqrt{\frac{(i_1^2+i_2^2)}{2}}$ (d) $\sqrt{\frac{(i_1-i_2)^2}{2}}$

17. A charge + q is placed at each of the points $x = x_0, x = 3x_0, x = 5x_0, x = 7x_0$ ....∞ on the x-axis and a charge -q is placed at each of the points $x = 2x_0, x = 4x_0, x = 6x_0, x = 8x_0$ ....∞ here x_0 is a positive constant. Take the electric potential at a point due to a charge q at a distance r from it to be $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$. The electric potential at the origin due to the above system of charges is

(a) zero (b) $\frac{1}{4\pi\varepsilon_0}\frac{q}{x_0}\ln 2$ (c) $\frac{1}{4\pi\varepsilon_0}\frac{q}{x_0 2\ln 2}$ (d) infinite

18. The Nucleus $^{23}_{10}Ne$ decays by $\beta -$ emission through the reaction $^{23}_{10}Ne \rightarrow {}^{23}_{11}Na + {}^{0}_{-1}\beta + \bar{\upsilon} + energy$ The atomic masses are $^{23}_{10}Ne = 22.994466u$ and $^{23}_{11}Na = 22.989770u$, $^{0}_{-1}\beta = 0.000549$ u. The maximum kinetic energy that the emitted electron can ever have is

(a) 4.374 MeV (b) 3.862 MeV (c) 2.187 MeV (d) 1.931 MeV

19. The distance between two slits in Young's double slits experiment is $d = 2.5$ mm and the distance of the screen from the plane of slits is $D = 120$ cm. The slits are illuminated with coherent beam of light of wavelength $\lambda = 600$ nm. The minimum distance (from the central maximum) of a point where the intensity reduces to 25% of maximum intensity is

(a) 24 μm (b) 48 μm (c) 96 μm (d) 120 μm

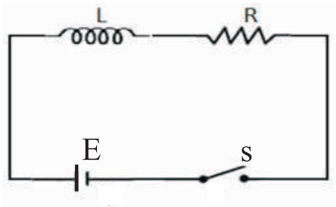
20. What amount of heat will be generated in a coil of resistance R (ohm) due to a total charge Q (coulomb) passing through it if the current in the coil decreases down to zero halving its value every Δt second?

(a) $\frac{1}{2}\frac{Q^2R}{\Delta t}$ (b) $\frac{Q^2R}{\Delta t}\ln 2$ (c) $\frac{1}{2}\frac{Q^2R}{\Delta t}\ln 2$ (d) $\frac{1}{4}\frac{Q^2R}{\Delta t}$

21. In the L R circuit shown in figure, switch S is closed at time $t = 0$, the charge that passes through the battery of emf E in one time constant is (e being the base of natural logarithm).

(a) $\frac{EL}{eR^2}$ (b) $\frac{EL}{eR}$

(c) $\frac{eER^2}{L}$ (d) $\frac{EL}{R}$



22. Natural Uranium is a mixture of $^{238}_{92}U$ and $^{235}_{92}U$ with a relative mass abundance of 140 : 1. The ratio of radioactivity contributed by the two isotopes of natural uranium, if their half-lives are 4.5×10^9 years and 7.0×10^8 years respectively is

(a) 99.3 : 0.7 (b) 50.3 : 49.7 (c) 95.6 : 04.4 (d) cannot be estimated

23. A cylinder of length $\ell > 1$m filled with water ($\mu = \frac{4}{3}$) up to the brim, kept on a horizontal table is covered at its top by an equiconvex glass ($\mu = 1.5$) lens of focal length 25 cm when in air. At mid day, 12.00 noon, Sun is just overhead and light rays comes parallel to the principal axis of the lens. The sun rays will be focused

(a) 25 cm behind the lens in the water (b) 37.5 cm behind the lens in the water
(c) 50 cm behind the lens in the water (d) 100 cm behind the lens in the water

24. Even the radiation of highest wave length in the ultraviolet region of hydrogen spectrum is just able to eject photoelectrons from a metal. The value of threshold frequency for the given metal is

(a) 3.83×10^{15} Hz (b) 4.33×10^{14} Hz (c) 2.46×10^{15} Hz (d) 7.83×10^{14} Hz

A - 2
ANY NUMBER OF OPTIONS 4, 3, 2 or 1 MAY BE CORRECT
MARKS WILL BE AWARDED ONLY IF ALL CORRECT OPTIONS ARE BUBBLED AND NO WRONG OPTION

25. A parallel plate capacitor of plate area A and plate separation d is charged to potential V. Then the battery is disconnected. A slab of dielectric constant k is then inserted between the plates of the capacitor so as to fill the space between the plates completely. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done on the system, in question, in the process of inserting the slab, then

(a) $Q = k\varepsilon_0 AE$ (b) $Q = \dfrac{\varepsilon_0 kAV}{d}$ (c) $E = \dfrac{V}{kd}$ (d) $W = \dfrac{\varepsilon_0 AV^2}{2d}(1 - \dfrac{1}{k})$

26. The magnitudes of the gravitational field at distances r_1 and r_2 from the centre of a uniform solid sphere of radius R and mass M are $F(r_1)$ and $F(r_2)$ respectively. Such that

(a) $\dfrac{F(r_1)}{F(r_2)} = \dfrac{r_1}{r_2}$ if $r_1 \le R$ and $r_2 \le R$

(b) $\dfrac{F(r_1)}{F(r_2)} = \dfrac{r_2^2}{r_1^2}$ if $r_1 \ge R$ and $r_2 \ge R$

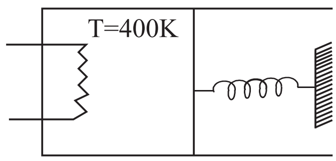
(c) $\dfrac{F(r_1)}{F(r_2)} = \dfrac{r_1}{r_2}$ if $r_1 \ge R$ and $r_2 \ge R$

(d) $\dfrac{F(r_1)}{F(r_2)} = \dfrac{r_1^2}{r_2^2}$ if $r_1 \le R$ and $r_2 \le R$

27. The intensity of sound at a point P is I_0, when the sounds reach this point directly and in same phase from two identical sources S_1 and S_2. The power of S_1 is now reduced by 64 % and the phase difference (ϕ) between S_1 and S_2 is varied continuously. The maximum and minimum intensities recorded at P are now I_{max} and I_{min} such that

(a) $I_{max} = 0.64\, I_0$ (b) $I_{min} = 0.36\, I_0$ (c) $\dfrac{I_{max}}{I_{min}} = 16$ (d) $\dfrac{I_{max}}{I_{min}} = \dfrac{16}{9}$

28. An ideal monatomic gas is confined within a cylinder by a spring loaded piston of cross-sectional area 4×10^{-3} m^2. Initially the gas is at 400 K and occupies a volume 2×10^{-3} m^3 and the spring is in its relaxed position. The gas is heated by an electric heater for some time. During this time the gas expands and the piston moves out by a distance 0.1 m. The spring connected to the rigid wall is massless and frictionless. The force constant of the spring is 2000 Nm^{-1} and atmospheric pressure is 10^5 Nm^{-2} then



(a) The final temperature of the gas is 720 K.
(b) The work done by gas in expanding is 50 J
(c) The heat supplied by heater is 190 J
(d) The heat supplied by heater is 290 J

29. A particle of mass m is located in a one dimensional potential field U (x) = U_0 (1 - cos ax); U_0 and a are constants. Which of the following statement/s is/are correct?

(a) The particle will execute Simple Harmonic Motion for small displacements.

(b) The stable equilibrium condition is $x = 0$

(c) The time period of small oscillations is $\frac{2\pi}{a}\sqrt{\frac{m}{U_0}}$

(d) The angular frequency for small oscillations is $\omega = a\sqrt{\frac{U_0}{m}}$

30. A ray of light is incident on an equilateral prism made of flint glass (refractive index 1.6) placed in air.

(a) The ray suffers a minimum deviation if it is incident at angle 53^0.

(b) The minimum angle of deviation suffered by the ray is 46^0.

(c) If prism is immersed in water ($\mu = \frac{4}{3}$) the minimum deviation produced by the prism is 14^0.

(d) The minimum deviation produced by the prism is 23.6^0 if it is immersed in a liquid of refractive index $\mu = 1.2$

31. In a p-n junction diode, the current (i) varies with applied biasing voltage (V) and can be expressed as $i = i_0\left(e^{qV/kT} - 1\right)$ where $i_0 = 5 \times 10^{-12}$ A is reverse saturation current, k is Boltzmann constant and q is the charge on the electron

At Absolute Temperature $T = 300K$

(a) The forward current is approximately 59.5 mA for a forward bias of 0.6 volt

(b) The current increases approximately by 2.75A if the biasing voltage changes from 0.6 V to 0.7 V

(c) The dynamic resistance of p-n junction is approximately 435 mΩ at the biasing voltage of 0.6 V

(d) The change in reverse bias current when biasing voltage change from -1 volt to -2 volt happens to be practically zero.

32. A charged oil (density 880 kg m^{-3}) drop is held stationary between two parallel horizontal metal plates 6.0 mm apart when a potential difference of $V = 103$ volt is applied between the two plates. When the electric field is switched off, the drop falls. At a certain time the drop is seen to fall a distance of 2.0 mm in 35.7 s and next 1.2 mm in 21.4 s. (The upper plate in the experiment is at higher potential).

Given that the viscosity of air = 1.80×10^{-5} Nsm^{-2} and density of air = 1.29 kg m^{-3}

(a) The radius of the drop is $a = 7.25 \times 10^{-7}$m

(b) The charge on the drop is $q = 8.0 \times 10^{-19}$C

(c) The terminal velocity of the oil drop, under its free fall, is 5.6×10^{-5} ms^{-1}

(d) The oil drop carries 5 excess electrons

NATIONAL STANDARD EXAMINATION IN PHYSICS

NSEP - 2022

FINAL ANSWER KEY NSEP - 2022

QUESTION	PAPER CODE 61	PAPER CODE 62	PAPER CODE 63	PAPER CODE 64
1	d	b	d	b
2	c	a	a	b
3	c	a	b	a
4	c	c	b	c
5	a	b	a	c
6	a	c	c	b
7	b	b	b	a
8	a	d	a	a
9	a	c	a	c
10	c	d	c	b
11	b	a	b	c
12	c	b	c	b
13	b	b	b	d
14	d	a	d	c
15	c	c	c	d
16	d	d	d	a
17	a	a	a	b
18	b	c	c	b
19	b	b	b	a
20	a	b	b	c
21	c	b	b	d
22	d	a	a	a
23	a	c	c	c
24	c	c	c	b
25	b	a	a	a
26	b	c	c	c
27	b	c	c	c
28	a	c	c	c
29	c	d	d	d
30	c	c	c	c

QUESTION	PAPER CODE 61	PAPER CODE 62	PAPER CODE 63	PAPER CODE 64
31	a	b	b	b
32	c	d	d	d
33	c	d	d	d
34	c	c	c	c
35	d	a	a	a
36	c	b	b	b
37	b	c	c	c
38	d	c	c	c
39	d	a	a	a
40	c	b	b	b
41	a	a	a	a
42	b	a	a	a
43	c	d	d	d
44	c	c	c	c
45	a	c	c	c
46	b	c	c	c
47	a	a	a	a
48	a	a	a	a
49	b, c, d	a, b	b, c, d	b, c, d
50	a, b, c, d	a, c, d	a, b, c, d	a, b, c, d
51	a, b, d	a, b	a, b, d	a, b, d
52	a, c	a, d	a, b	a, b
53	b, c	b, c, d	a, c, d	a, c, d
54	a, b	a, b, c, d	a, b	a, b
55	a, b, c, d	a, b, d	a, d	a, d
56	a, b	a, c	a, c	a, c
57	a, c, d	b, c	b, c	b, c
58	a, b	a, b	a, b	a, b
59	a, d	a, b, c, d	a, b, c, d	a, b, c, d
60	a, c	a, c	a, c	a, c

P160

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2017 -18

Date of Examination: 26TH November, 2017

Time: 0830 to 1030 Hrs

Q. Paper Code: P160

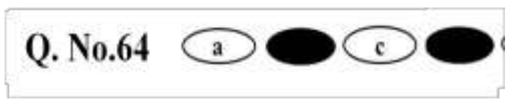
Write the question paper code mentioned above on YOUR answer sheet (in the space provided), otherwise your answer sheet will NOT be assessed. Note that the same Q. P. Code appears on each page of the question paper.

Instructions to Candidates –

1. Use of mobile phones, smartphones, ipads during examination is **STRICTLY PROHIBITED**.
2. In addition to this question paper, you are given answer sheet along with Candidate's copy.
3. On the answer sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/carelessly filled information may disqualify your candidature.
4. On the answer sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. The email ID and date birth entered in the answer sheet will be your login credentials for accessing performance report. Please take care while entering.
6. Question paper has two parts. In part A1 (Q. No. 1 to 60) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   In part A2 (Q. No. 61 to 70) each question has four alternatives out of which **any number of alternative (**1, 2, 3 or 4**) may be correct.** You have to choose ALL correct alternatives and fill the appropriate bubbles, as shown

7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Any rough work should be done only in the space provided.
9. Use of **non-programmable** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting your answer paper, take away the Candidate's copy for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the answer sheet.

Answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED.

Scratching or overwriting may result in a wrong score.

P160

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (continued) –

Read the following instructions after submitting the answer sheet.

12. **Comments regarding this question paper, if any, may be filled in Google forms only at https://goo.gl/forms/9GP03NRgUVuhWJn52 till 28th November, 2017.**
13. **The answers/solutions to this question paper will be available on our website – www.iapt.org.in by 2nd December, 2017.**
14. **CERTIFICATES and AWARDS –**
Following certificates are awarded by the IAPT to students successful in NSEs

    (i)Certificates to "Centre Top 10%" students

    (ii)Merit Certificates to "Statewise Top 1%" students

    (iii)Merit Certificates and a book prize to "National Top 1%" students

15. Result sheets can be downloaded from our website in the month of February. The "Centre Top 10%" certificates will be dispatched to the Prof-in-charge of the centre by February, 2018.
16. List of students (with centre number and roll number only) having score above MAS will be displayed on our website (www.iapt.org.in) by **22nd December, 2017.** See the **Eligibility Clause** in the Student's brochure on our website.
17. Students eligible for the INO Examination on the basis of selection criteria mentioned in Student's brochure will be informed accordingly.

Physical constants you may need…

Magnitude of charge on electron $e = 1.60 \times 10^{-19}$ C	Mass of electron $m_e = 9.10 \times 10^{-31}$ kg
Universal gas constant $R = 8.31$ J/mol K	Planck constant $h = 6.62 \times 10^{-34}$ Js
Stefan constant $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4	Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg	Faraday constant = 96,500 C/mol
Boiling point of nitrogen = 77.4 K	Boiling point of oxygen = 90.19 K
Boiling point of hydrogen = 20.3 K	Boiling point of helium = 4.2 K
Universal gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/ Kg^2	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2

P160

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS 2017-18
Total Time : 120 minutes (A-1 and A-2)

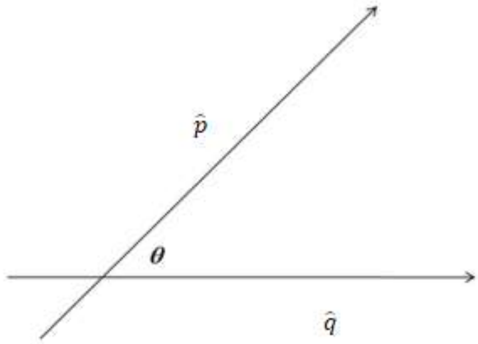
A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT.

1) Consider two point masses m_1 and m_2 connected by a light rigid rod of length r_0. The moment of inertia of the system about an axis passing through their centre of mass and perpendicular to the rigid rod is given by

(a) $\frac{m_1 m_2}{2(m_1+m_2)} r_0^2$ (b) $\frac{m_1 m_2}{m_1+m_2} r_0^2$ (c) $\frac{2m_1 m_2}{m_1+m_2} r_0^2$ (d) $\frac{m_1^2+m_2^2}{m_1+m_2} r_0^2$

2) Motion of a particle in a plane is described by the non-orthogonal set of coordinates (p, q) with unit vectors $(\hat{p}, \hat{q})$ inclined at an angle θ as shown in the diagram. If the mass of the particle is m, its kinetic energy is given by $\left(\dot{x} = \frac{dx}{dt}\right)$



(a) $\frac{1}{2}m(\dot{p}^2 + \dot{q}^2 + \dot{p}\dot{q}\cos\theta)$

(b) $\frac{1}{2}m\left(\dot{p}^2 + \dot{q}^2 - \dot{p}\dot{q}(1 - \sin\theta)\right)$

(c) $\frac{1}{2}m(\dot{p}^2 + \dot{q}^2 + 2\dot{p}\dot{q}\cos\theta)$

(d) $\frac{1}{2}m(\dot{p}^2 + \dot{q}^2 + \dot{p}\dot{q}\cot\theta)$

3) A man is going up in a lift (open at the top) moving with a constant velocity 3 m/s. He throws a ball up at 5 m/sec relative to the lift when the lift is 50 m above the ground. Height of the lift when the ball meets it during its downward journey is (g = 10 m/s^2)

(a) 53 m (b) 58 m (c) 63 m (d) 68 m

4) When a body is suspended from a fixed point by a spring, the angular frequency of its vertical oscillations is ω_1. When a different spring is used, the angular frequency is ω_2. The angular frequency of vertical oscillations when both the springs are used together in series is given by

(a) $\omega = [\omega_1^2 + \omega_2^2]^{½}$ (b) $\omega = [(\omega_1^2 + \omega_2^2)/2]^{½}$

(c) $\omega = [\omega_1^2\omega_2^2/(\omega_1^2 + \omega_2^2)]^{½}$ (d) $\omega = [\omega_1^2\omega_2^2/2(\omega_1^2 + \omega_2^2)]^{½}$

5) A small pond of depth 0.5 m deep is exposed to a cold winter with outside temperature of 263 K. Thermal conductivity of ice is K = 2.2 Wm^{-1}K^{-1}, latent heat $L = 3.4 \times 10^5$ Jkg^{-1} and density $\rho = 0.9 \times 10^3$ kgm^{-3}. Take the temperature of the pond to be 273 K. The time taken for the whole pond to freeze is about

(a) 20 days (b) 25 days (c) 30 days (d) 35 days

6) A body of mass 4 kg moves under the action of a force $\vec{F} = (4\hat{\imath} + 12t^2\hat{\jmath})$ N, where t is the time in second. The initial velocity of the particle is $(2\hat{\imath} + \hat{\jmath} + 2\hat{k})$ ms^{-1}. If the force is applied for 1 s, work done is

(a) 4 J (b) 8 J (c) 12 J (d) 16 J

7) A racing car moves along a circular track of radius b. The car starts from rest and its speed increases at a constant rate α. Let the angle between the velocity and the acceleration be θ at time t. Then $(\cos\theta)$ is

(a) 0 (b) $\alpha t^2/b$ (c) $b/(b + \alpha t^2)$ (d) $b/(b^2 + \alpha^2 t^4)^{1/2}$

8) A small fish, 4 cm below the surface of a lake, is viewed through a thin converging lens of focal length 30 cm held 2 cm above the water surface. Refractive index of water is 1.33. The image of the fish from the lens is at a distance of

(a) 10 cm (b) 8 cm (c) 6 cm (d) 4 cm

9) A horizontal ray of light passes through a prism of refractive index 1.5 and apex angle 4° and then strikes a vertical plane mirror placed to the right of the prism. If after reflection, the ray is to be horizontal, then the mirror must be rotated through an angle

(a) 1° clockwise
(b) 1° anticlockwise
(c) 2° clockwise
(d) 2° anticlockwise

10) An isolated metallic object is charged in vacuum to a potential V_0 using a suitable source, its electrostatic energy being W_0. It is then disconnected from the source and immersed in a large volume of dielectric with dielectric constant K. The electrostatic energy of the sphere in the dielectric is

(a) $K^2 W_0$ (b) $K W_0$ (c) W_0 / K^2 (d) W_0 / K

11) Two identical coils each of self-inductance L, are connected in series and are placed so close to each other that all the flux from one coil links with the other. The total self-inductance of the system is

(a) L (b) $2L$ (c) $3L$ (d) $4L$

12) A coil 2.0 cm in diameter has 300 turns. If the coil carries a current of 10 mA and lies in a magnetic field 5×10^{-2} T, the maximum torque experienced by the coil is

(a) 4.7×10^{-2} N-m (b) 4.7×10^{-4} N-m (c) 4.7×10^{-5} N-m (d) 4.7×10^{-8} N-m

13) A particle performs simple harmonic motion at a frequency f. The frequency at which its kinetic energy varies is

(a) f (b) $2f$ (c) $4f$ (d) $f/2$

14) In case of real images formed by a thin convex lens, the linear magnification is (I) directly proportional to the image distance, (II) inversely proportional to the object distance, (III) directly proportional to the distance of image from the nearest principal focus, (IV) inversely proportional to the distance of the object from the nearest principal focus. From these the correct statements are

(a) (I) and (II) only.
(b) (III) and (IV) only.
(c) (I), (II), (III) and (IV) all.
(d) None of (I), (II), (III) and (IV).

15) An infinitely long straight non-magnetic conducting wire of radius a carries a dc current I. The magnetic field B, at a distance r ($r < a$) from axis of the wire is

(a) $\mu_0 I/2\pi a$ (b) $\mu_0 Ir/2\pi a^2$ (c) $2\mu_0 Ir/\pi a^2$ (d) $\mu_0 Ir^2/2\pi a^3$

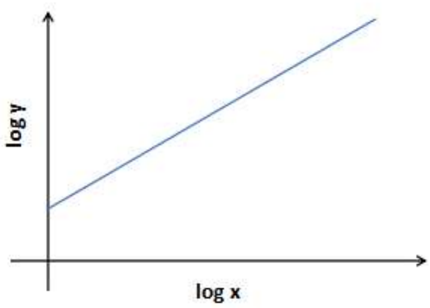
16) A quantity α is defined as $\alpha = e^2/4\pi\epsilon_0 c\,\hbar$, where e is electric charge, $\hbar = h/2\pi$ is the reduced Planck's constant and c is the speed of light. The dimensions of α are

(a) $[M^0 L^0 T^0 I^0]$ (b) $[M^1 L^{-1} T^2 I^{-2}]$ (c) $[M^2 L^1 T^{-1} I^0]$ (d) $[M^0 L^3 T^1 I^{-2}]$

17) The earth's magnetic field at a certain point is 7.0×10^{-5} T. This field is to be balanced by a magnetic field at the centre of a circular current carrying coil of radius 5.0 cm by suitably orienting it. If the coil has 100 turns then the required current is about

(a) 28 mA (b) 56 mA (c) 100 mA (d) 560 mA

18) The equation correctly represented by the following graph is (a and b are constants)



(a) $x + y = b$
(b) $ax^2 + by^2 = 0$
(c) $x + y = ab$
(d) $y = ax^b$

19) Which one of the following devices does not respond to the intensity of light incident on it?

(a) Photoresistor (LDR)
(b) Photodiode
(c) Light Emitting Diode
(d) Solar Cell

20) Consider a parallel plate capacitor. When half of the space between the plates is filled with some dielectric material of dielectric constant K as shown in Fig. (1) below, the capacitance is C_1. However, if the same dielectric material fills half the space as shown in Fig. (2), the capacitance is C_2. Therefore, the ratio $C_1 : C_2$ is

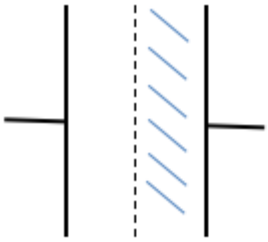


Fig. (1)

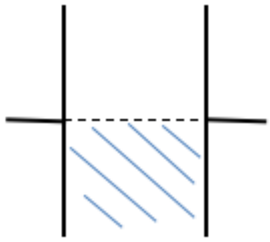


Fig. (2)

(a) 1 (b) $\frac{2K}{K+1}$ (c) $\frac{4K}{(K+1)^2}$ (d) $\frac{K+1}{2}$

21) A point source of light is viewed through a plate of glass of thickness t and of refractive index 1.5. The source appears

(a) closer by a distance $2t/3$
(b) closer by a distance $t/3$
(c) farther by a distance $t/3$
(d) farther by a distance $2t/3$

22) The fraction of the original number of nuclei of a radioactive atom having a mean life of 10 days, that decays during the 5^{th} day is

(a) 0.15 (b) 0.30 (c) 0.045 (d) 0.064

23) The photoelectric threshold wavelength of tungsten is 230 nm. The energy of electrons ejected from its surface by ultraviolet light of wavelength 180 nm is:

(a) 0.15 eV (b) 1.5 eV (c) 15 eV (d) 1.5 keV

24) A slit of width a is illuminated by parallel monochromatic light of wavelength λ. The value of a at which the first minimum of the diffraction pattern will form at $\theta = 30^o$ is

(a) $\lambda/2$ (b) λ (c) 2λ (d) 3λ

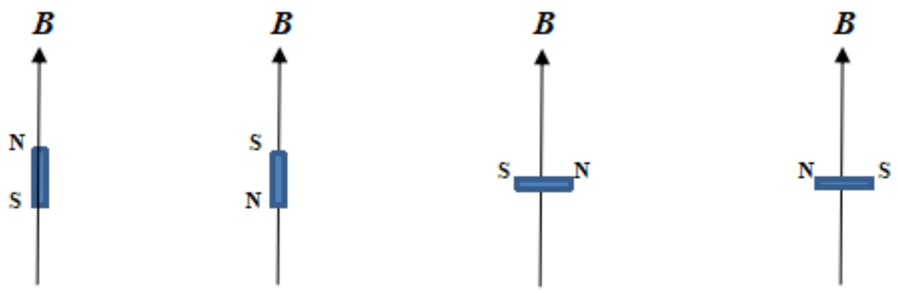
25) A whistle whose air column is open at both ends has a fundamental frequency 500 Hz. The whistle is dipped in water such that half of it remains out of water. What will be the fundamental frequency now? (speed of sound in air is 340 ms^{-1}).

(a) 250 Hz (b) 125 Hz (c) 500 Hz (d) 1000 Hz

26) The physical quantity that has unit volt-second is

(a) energy (b) electric flux (c) magnetic flux (d) inductance

27) Consider different orientations of a bar magnet lying in a uniform magnetic field as shown below. The potential energy is maximum in orientation



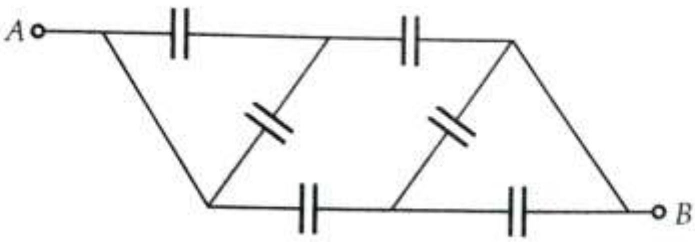
(a) 1 (b) 2 (c) 3 (d) 4

28) Two identical charged spheres suspended from a common point by two light strings of length l, are initially ata distance d ($<< l$) apart due to their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity v. If x denotes the distance between the spheres, then v varies as

(a) x^{-1} (b) $x^{1/2}$ (c) $x^{-1/2}$ (d) x

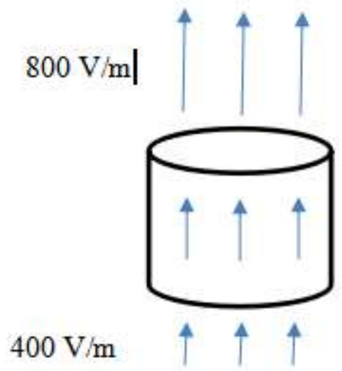
29) A network of six identical capacitors, each of capacitance C is formed as shown below. The equivalent capacitance between the points A and B is

(a) $3C$
(b) $6C$
(c) $3C/2$
(d) $4C/3$



30) A cylinder on whose surfaces there is a vertical electric field of varying magnitude as shown. The electric field is uniform on the top surface as well as on the bottom surface. Therefore, this cylinder encloses

(a) no net charge.
(b) net positive charge.
(c) net negative charge.
(d) There is not enough information to determine whether or not there is net charge inside the cylinder.



31) Two identical solid blocks A and B are made of two different materials. Block A floats in a liquid with half of its volume submerged. When block B is pasted over A, the combination is found to just float in the liquid. The ratio of the densities of the liquid, material of A and material of B is given by

(a) 1 : 2 : 3 (b) 2 : 1 : 4 (c) 2 : 1 : 3 (d) 1 : 3 : 2

32) In an X ray tube the electrons are expected to strike the target with a velocity that is 10% of the velocity of light. The applied voltage should be

(a) 517.6 V (b) 1052 V (c) 2.559 kV (d) 5.680 kV

33) When observed from the earth the angular diameter of the sun is 0.5 degree. The diameter of the image of the sun when formed in a concave mirror of focal length 0.5 m will be about

(a) 3.0 mm (b) 4.4 mm (d) 5.6 mm (e) 8.8 mm

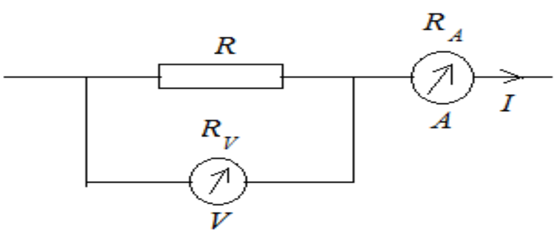
34) The decimal number that is represented by the binary number $(100011.101)_2$ is

(a) 23.350 (b) 35.625 (c) 39.245 (d) 42.455

35) The excess pressure inside a soap bubble is equal to 2 mm of kerosene (density 0.8 g cm^{-3}). If the diameter of the bubble is 3.0 cm, the surface tension of soap solution is

(a) 39.2 dyne cm^{-1} (b) 45.0 dyne cm^{-1}
(c) 51.1 dyne cm^{-1} (d) 58.8 dyne cm^{-1}

36) Let V and I be the readings of the voltmeter and the ammeter respectively as shown in the figure. Let R_V and R_A be their corresponding resistances. Therefore,



(a) $R = \frac{V}{I}$

(b) $R = \frac{V}{I - \left(\frac{V}{R_V}\right)}$

(c) $R = R_V - R_A$

(d) $R = \frac{V(R+R_A)}{IR_A}$

37) A man stands at rest in front of a large wall. A sound source of frequency 400 Hz is placed between him and the wall. The source is now moved towards the wall at a speed of 1m/s. The number of beats heard per second will be (speed of sound in air is 345 m/s)

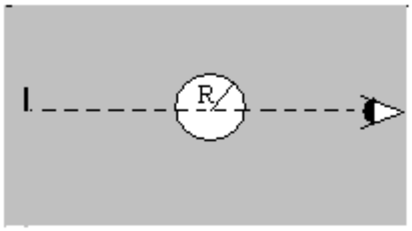
(a) 0.8 (b) 0.58 (c) 1.16 (d) 2.32

38) A hollow sphere of inner radius 9 cm and outer radius 10 cm floats half submerged in a liquid of specific gravity 0.8. The density of the material of the sphere is

(a) 0.84 g cm^{-3} (b) 1.48 g cm^{-3} (c) 1.84 g cm^{-3} (d) 1.24 g cm^{-3}

39) Rays from an object immersed in water (μ = 1.33) traverse a spherical air bubble of radius R. If the object is located far away from the bubble, its image as seen by the observer located on the other side of the bubble will be

(a) virtual, erect and diminished
(b) real, inverted and magnified
(c) virtual, erect and magnified
(d) real, inverted and diminished



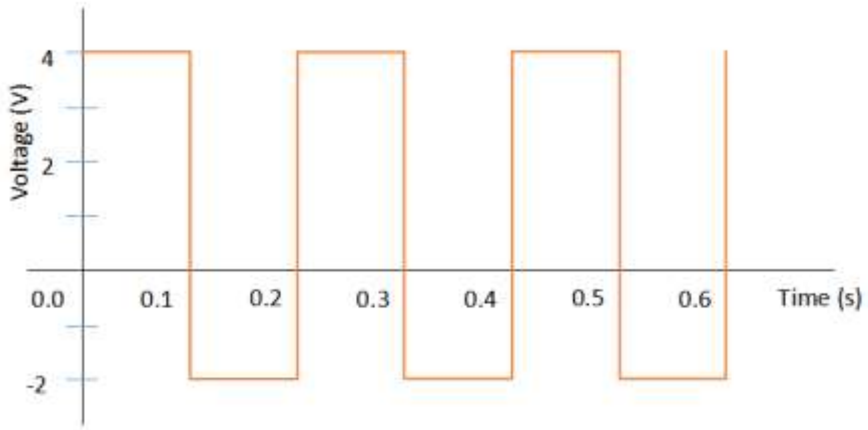
40) A 10 ohm resistor is connected to a supply voltage alternating between + 4V and – 2V as shown in the following graph. The average power dissipated in the resistor per cycle is

(a) 1.0 W

(b) 1.2 W

(c) 1.4 W

(d) 1.6 W



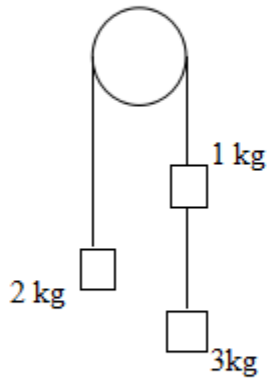
41) In the following arrangement the pulley is assumed to be light and the strings inextensible. The acceleration of the system can be determined by considering conservation of a certain physical quantity. The physical quantity conserved and the acceleration respectively, are

(a) energy and $g/3$

(b) linear momentum and $g/2$

(c) angular momentum and $g/3$

(d) mass and $g/2$



42) Two cells each of emf E and internal resistances r_1 and r_2 respectively are connected in series with an external resistance R. The potential difference between the terminals of the first cell will be zero when R is equal to

(a) $\frac{r_1+r_2}{2}$ (b) $\sqrt{r_1^2 - r_2^2}$ (c) $r_1 - r_2$ (d) $\frac{r_1 r_2}{r_1+r_2}$

43) A student uses a convex lens to determine the width of a slit. For this he fixes the positions of the object and the screen and moves the lens to get a real image on the screen. The images of the slit width are found to be 2.1 cm and 0.48 cm wide respectively when the lens is moved through 15 cm. Therefore, the slit width and the focal length of the lens respectively, are

(a) 1 cm, 9.3 cm (b) 1 cm, 10.5 cm (c) 2 cm, 12.8 cm (d) 2 cm, 15.2 cm

44) A particle rests in equilibrium under two forces of repulsion whose centres are at distances of a and b from the particle. The forces vary as the cube of the distance. The forces per unit mass are k and k' respectively. If the particle be slightly displaced towards one of them the motion is simple harmonic with the time period equal to

(a) $\frac{2\pi}{\sqrt{3\left(\frac{k}{a^3}+\frac{k'}{b^3}\right)}}$ (b) $\frac{2\pi}{\sqrt{\left(\frac{k}{a^3}+\frac{k'}{b^3}\right)}}$

(c) $\frac{2\pi}{\sqrt{\left(\frac{k}{a^4}+\frac{k'}{b^4}\right)}}$ (d) $\frac{2\pi}{\sqrt{3\left(\frac{k}{a^4}+\frac{k'}{b^4}\right)}}$

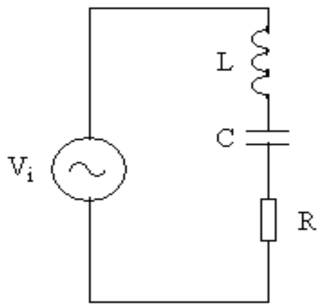
45) In the following circuit the current is in phase with the applied voltage. Therefore, the current in the circuit and the frequency of the source voltage respectively, are

(a) $\frac{V_i}{R}$ and $\frac{1}{2\pi\sqrt{LC}}$

(b) zero and $\frac{1}{\sqrt{LC}}$

(c) $\sqrt{\frac{C}{L}}\, V_i$ and $\frac{2}{\pi\sqrt{LC}}$

(d) $\sqrt[4]{\frac{C}{LR^2}}$ and $\frac{2}{\sqrt{LC}}$

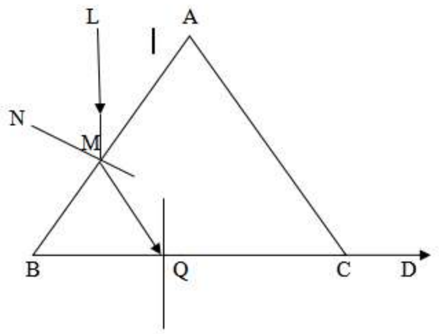


46) In an atom an electron excites to the fourth orbit. When it jumps back to the lower energy levels a spectrum is formed. Total number of spectral lines in this spectrum would be

(a) 3 (b) 4 (c) 5 (d) 6

47) The following figure shows the section ABC of an equilateral triangular prism. A ray of light enters the prism along LM and emerges along QD. If the refractive index of the material of the prism is 1.6, angle LMN is

(a) 35.6^0
(b) 37.4^0
(c) 39.4^0
(d) 41.3^0



48) A ball of mass *m* hits directly another ball of mass *M* at rest and is brought to rest by the impact. One third of the kinetic energy of the ball is lost due to the collision. The coefficient of restitution is

(a) 1/3 (b) ½ (c) 2/3 (d) $\sqrt{\frac{2}{3}}$

49) An object 1 cm long lies along the principal axis of a convex lens of focal length 15 cm, the centre of the object being at a distance of 20 cm from the lens. Therefore, the size of the image is

(a) 0.3 cm. (b) 3 cm. (c) 9 cm. (d) 12 cm.

50) Acidified water from certain reservoir kept at a potential *V* falls in the form of small droplets each of radius *r* through a hole into a hollow conducting sphere of radius *a*. The sphere is insulated and is initially at zero potential. If the drops continue to fall until the sphere is half full, the potential acquired by the sphere is

(a) $\frac{a^2V}{2r^2}$ (b) $\sqrt{\frac{a}{r}}\frac{V}{2}$ (c) $\frac{a^3V}{2r^3}$ (d) $\frac{aV}{r}$

***Group of question Nos 51 to 55** are based on the following paragraph and its subsequent continuation after some questions.*

The following questions are concerned with experiments on the characterization and use of a moving coil galvanometer.

The series combination of a variable resistance *R*, one 100 Ω resistor and a moving coil galvanometer is connected to a mobile phone charger having negligible internal resistance. The zero of the galvanometer lies at the centre and the pointer can move 30 divisions full scale on either side depending on the direction of current. The reading of the galvanometer is 10 divisions and the voltages across the galvanometer and 100 Ω resistor are respectively 12 mV and 16 mV.

51) The figure of merit of the galvanometer in microampere per division is

(a) 16 (b) 20 (c) 32 (d) 10

52) The resistance of the galvanometer in ohm is

(a) 50 Ω. (b) 75 Ω. (c) 100 Ω. (d) 80 Ω.

The series combination of the galvanometer with a resistance of R is connected across an ideal voltage supply of 12V and this time the galvanometer shows full scale deflection of 30 divisions.

53) The value of R is nearly

(a) 12.5 kΩ. (b) 25 kΩ. (c) 75 kΩ. (d) 100 kΩ.

54) A 24 Ω resistance is connected to a 5 V battery with internal resistance of 1 Ω. A 25 kΩ resistance is connected in series with the galvanometer and this combination is used to measure the voltage across the 24 Ω resistance. The number of divisions shown in the galvanometer is

(a) 6. (b) 8. (c) 10. (d) 12.

55) Now a 1000 μF capacitor is charged using the 12 V supply and is discharged through the galvanometer-resistance combination used in the previous question. The current i (in ampere) at different time t (in second) are recorded. A graph of (ln i) against (t) is plotted. The slope of the graph is

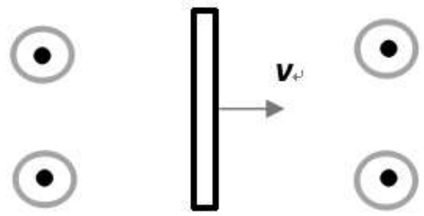
(a) $-0.02\ s^{-1}$ (b) $-0.01\ s^{-1}$ (c) $-0.04\ s^{-1}$ (d) $+0.04\ s^{-1}$

56) If Newton's inverse square law of gravitation had some dependence on radial distance other than r^{-2}, which one of Kepler's three laws of planetary motion would remain unchanged?

(a) First law on nature of orbits
(b) Second law on constant areal velocity
(c) Third law on dependence of orbital time period on orbit's semi major axis
(d) None of the above

57) A neutral metal bar moves at a constant velocity v to the right through a region of uniform magnetic field directed out of the page, as shown.

Therefore,



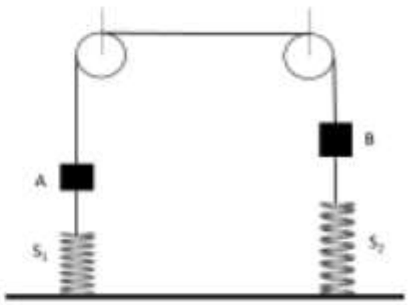
(a) positive charges accumulate to the left side and negative charges to the right side of the rod.
(b) negative charges accumulate to the left side and positive charges to the right side of the rod.
(c) positive charges accumulate to the top end and negative charges to the bottom end of the rod.
(d) negative charges accumulate to the top end and positive charges to the bottom end of the rod.

58) Two moles of hydrogen are mixed with n moles of helium. The root mean square speed of gas molecules in the mixture is $\sqrt{2}$ times the speed of sound in the mixture. Then n is

(a) 3 (b) 2 (c) 1.5 (d) 2.5

59) In the figure shown below masses of blocks A and B are 3 kg and 6 kg respectively. The force constants of springs S_1 and S_2 are 160 N/m and 40 N/m respectively. Length of the light sring connecting the blocks is 8 m. The system is released from rest with the springs at their natural lengths. The maximum elongation of spring S_1 will be

(a) 0.294 m
(b) 0.490 m
(c) 0.588 m
(d) 0.882 m



60) Two particles A and B of equal masses have velocities $\vec{v_A} = 2\hat{\imath} + \hat{\jmath}$ and $\vec{v_B} = -\hat{\imath} + 2\hat{\jmath}$. The particles move with accelerations $\vec{a_A} = -4\hat{\imath} - \hat{\jmath}$ and $\vec{a_B} = -2\hat{\imath} + 3\hat{\jmath}$ respectively. The centre of mass of the two particles moves along

(a) a straight line (b) a parabola
(c) a circle (d) an ellipse

P160

A2

QUESTIONS WITH MORE THAN ONE OPTION CORRECT

61) A ray is incident on a refracting surface of RI μ at an angle of incidence i and the corresponding angle of refraction is r. The deviation of the ray after refraction is given by $\delta = i\text{-}r$. Then, one may conclude that

(a) r increases with I (b) δ increases with i

(c) δ decreases with I (d) the maximum value of δ is $\cos^{-1}(\frac{1}{\mu})$

62) In a series R-C circuit the supply voltage (Vs) is kept constant at 2V and the frequency f of the sinusoidal voltage is varied from 500 Hz to 2000 Hz. The voltage across the resistance R = 1000 ohm is measured each time as V_R. For the determination of the C a student wants to draw a linear graph and try to get C from the slope. Then she may draw a graph of

(a) f^2 against V_R^2 (b) $\frac{1}{f^2}$ against $\frac{V_S^2}{V_R^2}$

(c) $\frac{1}{f^2}$ against $\frac{1}{V_R^2}$ (d) f against $\frac{V_R}{\sqrt{V_S^2 - V_R^2}}$

63) Two balls A and B moving in the same direction collide. The mass of B is p times that of A. Before the collision the velocity of A was q times that of B. After the collision A comes to rest. If e be the coefficient of restitution then which of the following conclusion/s is/are correct?

(a) $e = \frac{p+q}{pq-p}$ (b) $e = \frac{p+q}{pq+p}$

(c) $p \geq \frac{q}{q-2}$ (d) $p \geq 1$

64) A convex lens and a concave lens are kept in contact and the combination is used for the formation of image of a body by keeping it at different places on the principal axis. The image formed by this combination of lenses can be

(a) Magnified, inverted and real (b) Diminished, inverted and real
(c) Diminished, erect and virtual (d) Magnified, erect and virtual

65) In a bipolar junction transistor

(a) the most heavily doped region is the emitter.
(b) the level of doping is the same in both the emitter and the collector.
(c) its base is the thinnest part.
(d) when connected in common emitter configuration a base current is generally of the order of μA.

66) A particle starting from rest at the highest point slides down the outside of a smooth vertical circular track of radius 0.3 m. When it leaves the track its vertical fall is h and the linear velocity is v. The angle made by the radius at that position of the particle with the vertical is θ. Now consider the following observations: (g = 10 m/s^2)

(I) $h = 0.1$ m and $\cos\theta = ⅔$. (II) $h = 0.2$ m and $\cos\theta = ⅓$. (III) $v = \sqrt{2}$ ms^{-1}. (IV) After leaving the circular track the particle will describe a parabolic path.

Therefore,

(a) (I) and (III) both are correct.
(b) only (II) is incorrect.
(c) only (III) is correct.
(d) (IV) is correct.

67) A small bar magnet is suspended by a thread. A torque is applied and the magnet is found to execute angular oscillations. The time period of oscillations

(a) decreases with the moment of the magnet.
(b) increases with the increase of the horizontal component of the earth's magnetic field
(c) will remain unchanged even if another magnet is kept at a distance.
(d) depends on the mass of the magnet.

68) Two identical rods made of two different metals A and B with thermal conductivities K_A and K_B respectively are joined end to end. The free end of A is kept at a temperature T_1 while the free end of B is kept at a temperature T_2 (< T_1). Therefore, in the steady state

(a) the temperature of the junction will be determined only by K_A and K_B.
(b) if the lengths of the rods are doubled the rate of heat flow will be halved.
(c) if the temperatures at the two free ends are interchanged the junction temperature will change.
(d) the composite rod has an equivalent thermal conductivity of $\frac{2K_AK_B}{K_A+K_B}$.

69) If a system is made to undergo a change from an initial state to a final state by adiabatic process only, then
(a) the work done is different for different paths connecting the two states.
(b) there is no work done since there is no transfer of heat.
(c) the internal energy of the system will change.
(d) the work done is the same for all adiabatic paths.

70) A body of mass 1.0 kg moves in X-Y plane under the influence of a conservative force. Its potential energy is given by $U = 2x + 3y$ where (x, y) denote the coordinates of the body. The body is at rest at $(2, -4)$ initially. All the quantities have SI units. Therefore, the body

(a) moves along a parabolic path.
(b) moves with a constant acceleration.
(c) never crosses the X axis.
(d) has a speed of $2\sqrt{13}$ m/s at time $t = 2$ s.

-x-x-x-x-x-x-

Answer keys for NSEP- 2017. Please send your suggestions to the answer keys by filling the Google forms using the link given below. The last date for suggestions will be December 4th 2017. The corrections to final answer keys if any will be displayed on December 10th 2017. Google forms **link: https://goo.gl/forms/9GP03NRgUVuhWJn52**

QP code P160			QP code P161			QP code P162			QP code P163	
Question	Answer Key		Question	Answer Key		Question	nswer Key		Question	Answer Key
1	b		1	c		1	a		1	c
2	c		2	a		2	c		2	a
3	a		3	c		3	a		3	b
4	c		4	a		4	b		4	c
5	a		5	b		5	deleted		5	a
6	d		6	b		6	c		6	a
7	d		7	d		7	d		7	b
8	c		8	b		8	c		8	d
9	a		9	b		9	c		9	c
10	d		10	b		10	a		10	a
11	d		11	c		11	c		11	d
12	c		12	b		12	d		12	c
13	b		13	a		13	d		13	c
14	b		14	c		14	b		14	b
15	b		15	b		15	c		15	b
16	a		16	b		16	a		16	a
17	b		17	d		17	b		17	a
18	d		18	a		18	a		18	a
19	c		19	c		19	b		19	c
20	c		20	c		20	b		20	c
21	b		21	deleted		21	d		21	a
22	d		22	c		22	d		22	b
23	b		23	d		23	c		23	b
24	c		24	d		24	a		24	d
25	c		25	c		25	d		25	c
26	c		26	b		26	c		26	deleted
27	b		27	c		27	b		27	a
28	c		28	a		28	a		28	b
29	d		29	a		29	b		29	c
30	b		30	a		30	a		30	a
31	c		31	c		31	a		31	b
32	c		32	b		32	b		32	a
33	b		33	c		33	b		33	d
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35	d		35	c		35	c		35	d
36	b		36	d		36	b		36	d
37	c		37	a		37	b		37	b
38	b		38	c		38	a		38	c
39	a		39	a		39	a		39	d
40	a		40	d		40	a		40	c
41	a		41	a		41	c		41	a
42	c		42	b		42	c		42	c
43	a		43	b		43	c		43	c
44	deleted		44	d		repeated	repeated		44	b
45	a		45	c		44	a		45	b

46	a		46	deleted		45	c		46	a
47	a		47	c		46	d		47	b
48	deleted		48	d		47	b		48	d
49	c		49	d		48	c		49	b
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52	b		52	b		51	a		52	c
53	b		53	a		52	c		53	c
54	d		54	b		53	b		54	b
55	c		55	b		54	c		repeated	repeated
56	b		56	c		55	b		56	b
57	d		57	d		56	d		57	d
58	b		58	a		57	b		58	a
59	a		59	c		58	d		59	c
60	c		60	a		59	c		60	b
A2										
61	a,b,d		61	b,c,d		61	a,b,c,d		61	a,c,d
62	b,c,d		62	c,d		62	c,d		62	a,b,c,d
63	a,c,d		63	d		63	a,c,d		63	d
64	a,b,c,d		64	b,c,d		64	b,c,d		64	b,c,d
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68	b,c,d		68	a,b,c,d		68	b,c,d		68	a,b,d
69	c,d		69	b,c,d		69	a,c,d		69	b,c,d
70	b,c,d		70	a,b,d		70	b,c,d		70	a,c,d

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2019 - 20

Date of Examination: November 24, 2019

Time: 8:30 AM to 10:30 AM

Question Paper Code: 61

Student's Roll No:										

Write the question paper code mentioned above on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be assessed. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:

1. Use of mobile phones, smart watches, and ipads during examination is STRICTLY **PROHIBITED**.
2. In addition to this question paper, you are given OMR Answer Sheet along with Candidate's copy.
3. On the answer sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.

   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE** or **BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **ten-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in NSE - 2019.
6. Question paper has two parts. In part A1 (Q. No.1 to 60) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   Q.No.22 (a) ● (c) (d)

   In part A2 (Q. No. 61 to 70) each question has four alternatives out of which any number of alternative (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternatives fill the appropriate bubbles, as shown

   Q.No. 64 (a) ● (c) ●
7. For **Part A1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2,** you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Any rough work should be done only in the space provided.
9. Use of **non- programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting your answer paper, take away the Candidate's copy for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the answer sheet.

Answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (Continued) :

You may read the following instructions after submitting the answer sheet.

12. **Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iaptexam.in on the specified format till November 27, 2019.**
13. **The answers/solutions to this question paper will be available on the website: www.iapt.org.in by December 2, 2019.**
14. **CERTIFICATES and AWARDS:**

    Following certificates are awarded by IAPT to students, successful in the NATIONAL STANDARD EXAMINATION IN PHYSICS - 2019

    (i) "CENTRE TOP 10 %"

    (ii) "STATE TOP 1 %"

    (iii) "NATIONAL TOP 1 %"

    (iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC - 2020 at HBCSE Mumbai
15. All these certificates (except Gold Medal) will be sent/dispatched to the centre in-charge by February 1, 2020 along with the result sheet of the centre.
16. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: www.iapt.org.in by **December 20, 2019. See the Minimum Admissible score Clause** on the Student's brochure on the web.
17. List of Students eligible for Indian National Physics Olympiad (INPhO-2020) shall be displayed on www.iapt.org.in by December 28, 2019. These students have to register/enroll themselves on the website: Olympiads.hbcse.tifr.in of HBCSE Mumbai within the specified period.

Physical constants you may need….

Magnitude of charge on electron $e = 1.60\times10^{-19}$ C	Boiling point of hydrogen = 20.3K
Mass of electron $m_e = 9.10\times10^{-31}$kg	Boiling point of helium = 4.2K
Mass of proton $m_p = 1.67\times10^{-27}$kg	Boiling point of nitrogen = 77.4K
Acceleration due to gravity $g = 9.8$ ms^{-2}	Boiling point of oxygen = 90.19K
Universal gravitational constant $G = 6.67\times10^{-11}$ Nm^2/Kg^2	Permittivity of free space $\varepsilon_0 = 8.85\times10^{-12}$ C^2 / Nm^2
Universal gas constant R = 8.31 J / mol K	Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ H/m
Boltzmann constant $k = 1.38\times10^{-23}$ J / K	Planck's constant $h = 6.62\times10^{-34}$ Js
Stefan's constant $\sigma = 5.67\times10^{-8}$ W / m^{2}K^4	Faraday constant = 96,500C / mol
Rydberg constant $R = 1.097\times10^{7}$ m^{-1}	

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS 2019 - 20
(NSEP 2019 - 20)

Time: 120 minute **Max. Marks: 240**

Attempt All Seventy Questions

A - 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT.

1) An observer stands on the platform at the front edge of the first bogie of a stationary train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

(a) 1.07s (b) 0.98s (c) 0.91s (d) 0.81s

2) The resistive force on an aeroplane flying in a horizontal plane is given by $F_f = kv^2$, where k is constant and v is the speed of the aeroplane. When the power output from the engine is P_0, the plane flies at a speed v_0. If the power output of the engine is doubled the aeroplane will fly at a speed of

(a) $1.12\ v_0$ (b) $1.26\ v_0$ (c) $1.41\ v_0$ (d) $2.82\ v_0$

3) A 3.0 cm thick layer of oil (density $\rho_{oil} = 800\ kg/m^3$) floats on water (density $\rho_w = 1000\ kg/m^3$) in a transparent glass beaker. A solid cylinder is observed floating vertically with $\frac{1}{3}$ of it in water and $\frac{1}{3}$ in the oil. Oil is gently poured into the beaker until the cylinder floats in oil only. The fraction of the solid cylinder in oil now is

(a) $\frac{3}{5}$ (b) $\frac{2}{3}$ (c) $\frac{3}{4}$ (d) $\frac{8}{9}$

4) A wedge of mass M rests on a horizontal frictionless surface. A block of mass m starts sliding down the rough inclined surface of the wedge to its bottom. During the course of motion, the centre of mass of the block and the wedge system

(a) does not move at all

(b) moves horizontally with constant speed

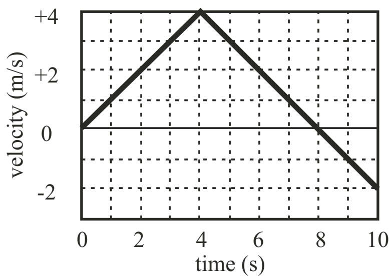
(c) moves horizontally with increasing speed

(d) moves vertically with increasing speed

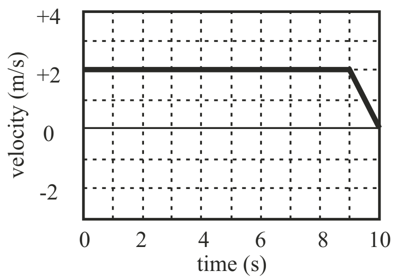
5) A uniform circular disc rotating at a fixed angular velocity ω about an axis normal to its plane and passing through its centre has kinetic energy E. If the same disc rotates with an angular velocity 2ω about a parallel axis passing through the edge, its kinetic energy will be

(a) 2 E (b) 4 E (c) 10E (d) 12 E

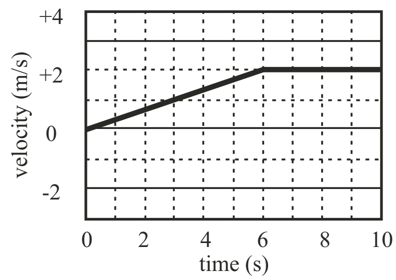
6) In the following figures the velocity-time graphs for three particles 1, 2 and 3 are shown.



Particle 1



Particle 2

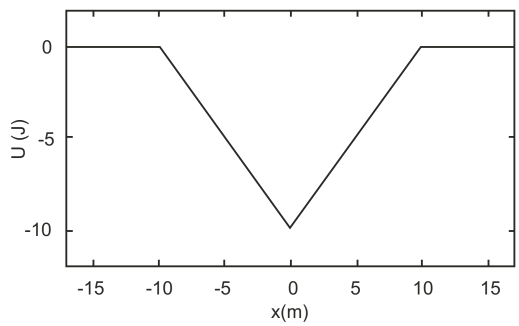


Particle 3

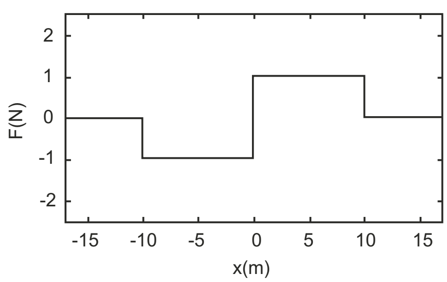
The magnitude of average acceleration of the three particles, over 10 s, bear the relationship

(a) $a_1 > a_2 > a_3$ (b) $a_2 > a_1 > a_3$ (c) $a_3 > a_2 > a_1$ (d) $a_1 = a_2 = a_3$

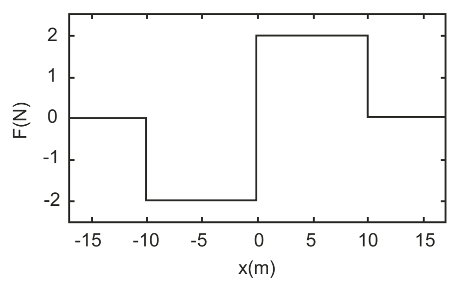
7) The potential energy (U) of a particle moving in a potential field varies with its displacement (x) as shown below.



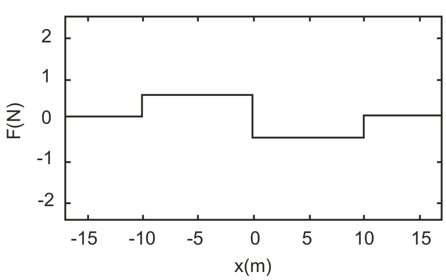
The variation of force F(x) acting on the particle as a function of x can be represented by



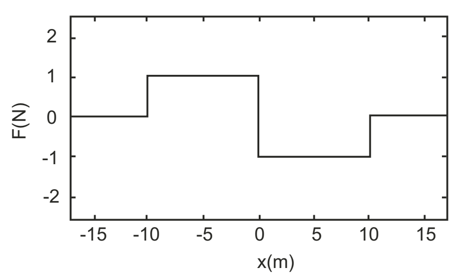
(Fig i)



(Fig ii)



(Fig iii)



(Fig iv)

(a) Fig (i) (b) Fig (ii) (c) Fig (iii) (d) Fig (iv)

8) A pendulum is made by using a thread of length 300 cm and a small spherical bob of mass 100 g. It is suspended from a point S. The bob is pulled from its position of rest at O to the point A so that the linear amplitude is 25 cm. The angular amplitude in radian and the potential energy of the bob in joule at A are respectively

a) 0.10 and 0.10 (b) 0.083 and 0.01 (c) 0.251 and 2.94 (d) 0.083 and 0.24

9) Consider the following physical expressions

(I) ρv^2 (ρ: density, v: velocity)

(II) $\frac{Y\Delta L}{L}$ (Y: Young's modulus, L: length)

(III) $\frac{\sigma^2}{\varepsilon_0}$ (σ: surface density of charge)

(IV) $h\rho rg$ (h: rise of a liquid in a capillary tube of radius r)

The expressions having same dimensional formula are

(a) I and II only
(b) II and III only
(c) II, III and IV only
(d) I, II and III only

10) Two simple pendulums of lengths 1.44 m and 1.0 m start swinging together in the same phase. The two will be in phase again after a time of

(a) 6 second (b) 9 second (c) 12 second (d) 25 second

11) A home aquarium partly filled with water slides down an inclined plane of inclination angle θ with respect to the horizontal. The surface of water in the aquarium

(a) remains horizontal.
(b) remains parallel to the plane of the incline.
(c) forms an angle α with the horizon where $0 < \alpha < \theta$
(d) forms an angle α with horizon, where $\theta < \alpha < 90$

12) A sound source of constant frequency travels with a constant velocity past an observer. When it crosses the observer the sound frequency sensed by the observer changes from 449 Hz to 422 Hz. If the velocity of sound is 340 m/s, the velocity of the source of sound is

(a) 8.5 m/s (b) 10.5 m/s (c) 12.5 m/s (d) 14.5 m/s

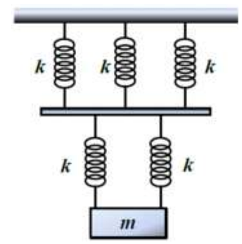
13) Light of wavelength 640 nm falls on a plane diffraction grating with 12000 lines per inch. In the diffraction pattern on a screen kept at a distance of 12 cm from the grating, the distance of the second order maximum from the central maximum is

(a) 1.81 cm (b) 2.41 cm (c) 3.62 cm (d) 7.25 cm

14) If the force acting on a body is inversely proportional to its speed, the kinetic energy of the body varies with time t as

(a) t^0 (b) t^1 (c) t^2 (d) t^{-1}

15) As shown in the figure, a block of mass m is hung from the ceiling by the system of springs consisting of two layers. The force constant of each of the springs is k. The frequency of the vertical oscillations of the block is



(a) $\frac{1}{2\pi}\sqrt{\frac{k}{5m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{4k}{5m}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{5k}{6m}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

16) Two simple harmonic motions are given by $x_1 = a\sin\omega t + a\cos\omega t$ and $x_2 = a\sin\omega t + \frac{a}{\sqrt{3}}\cos\omega t$ The ratio of the amplitudes of the first to the second and the phase difference between them respectively are

(a) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{12}$ (b) $\frac{\sqrt{3}}{2}$ and $\frac{\pi}{12}$ (c) $\frac{2}{\sqrt{3}}$ and $\frac{\pi}{12}$ (d) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{6}$

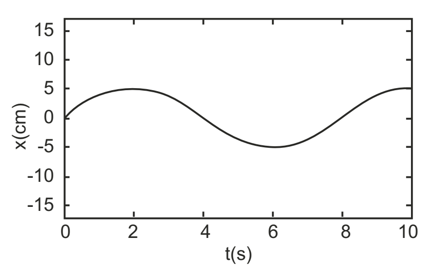
17) A particle is projected from the ground with a velocity $\vec{v} = (3\hat{i} + 10\hat{j})\ ms^{-1}$. The maximum height attained and the range of the particle are respectively given by (use $g = 10\ m/s^2$)

(a) 5m and 6 m (b) 3m and 10 m (c) 6m and 5 m (d) 3m and 5 m

18) A 20 cm long capillary tube stands vertically with lower end just in water. Water rises up to 5 cm. If the entire system is now kept on a freely falling platform, the length of the water column in the capillary tube will be

(a) 5 cm (b) 10 cm (c) Zero (d) 20 cm

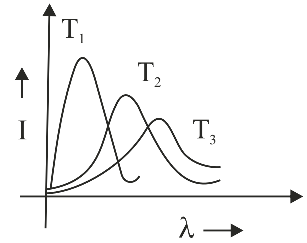
19) Position-time graph of a particle moving in a potential field is shown beside. If the mass of the particle is 1 kg its total energy is approximately



(a) 15.45×10^{-4} J (b) 30.78×10^{-4} J

(c) 7.71×10^{-4} J (d) 3.85×10^{-4} J

20) Plots of intensity (I) of radiation emitted by a black body versus wavelength (λ) at three different temperatures T_1, T_2 and T_3 respectively are shown in figure. Choose the correct statement.



(a) $T_1>T_2>T_3$ necessarily (b) $T_3>T_2>T_1$ necessarily

(c) $T_2 = (T_1 + T_3)/2$ necessarily (d) $T_2^2 = T_1 T_3$ necessarily

21) Consider a composite slab consisting of two different materials having equal thickness and equal area of cross-section. The thermal conductivities are K and 2K respectively. The equivalent thermal conductivity of the composite slab is

(a) $\frac{2K}{3}$ (b) $\sqrt{2}K$ (c) 3K (d) $\frac{4K}{3}$

22) A large horizontal uniform disc can rotate freely about a rigid vertical axis passing through its centre O. A man stands at rest at the edge of the disc at a point A. The mass of the disc is 22 times the mass of the man. The man starts moving along the edge of the disc. When he reaches A, after completing one rotation relative to the disc, the disc has turned through

(a) 30^o (b) 90^o (c) 60^o (d) 45^o

23) Two factories are sounding their sirens at 400 Hz each. A man walks from one factory towards the other at a speed of 2 m/s. The velocity of sound is 320 m/s. The number of beats heard by the person in one second will be

(a) 6 (b) 5 (c) 4 (d) 2.5

(24) The temperature of an isolated black body falls from T_1 to T_2 in time t. Then, t = C x where x is

(a) $\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ (b) $\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right)$ (c) $\left(\frac{1}{T_2^3} - \frac{1}{T_1^3}\right)$ (d) $\left(\frac{1}{T_2^4} - \frac{1}{T_1^4}\right)$

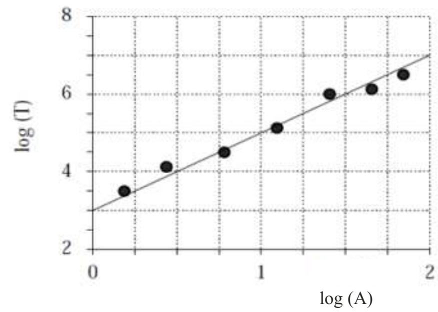
25) Two charges – q and – q are placed at points (0, d) and (0, – d). A charge +q, free to move along X axis, will oscillate with a force proportional to

(a) $\frac{1}{x^2+d^2}$ (b) $\frac{1}{x^2}$ (c) $\frac{x}{(d^2+x^2)^{\frac{3}{2}}}$ (d) $\frac{1}{\sqrt{x^2+d^2}}$

26) The average translational kinetic energy of oxygen (M = 32) molecules at a certain temperature is 0.048 eV. The translational kinetic energy of nitrogen (M = 28) molecules at the same temperature is (consider the two gases to be ideal)

(a) 0.0015 eV (b) 0.042 eV (c) 0.048 eV (d) 0.768 eV

27) The log-log graph for a non-linear oscillator is shown below. Assuming the constants to have appropriate dimensions the relationship between time period (T) and the amplitude (A) can be expressed as



(a) $T = 1000A^2$

(b) $T = 4A^{1/2}$

(c) $T = 4A^2 + B$

(d) $T = 8A^3$

28) In many situations the point source emitting a wave starts moving, through the medium, with velocity V greater than the wave velocity in that medium. In such a case when source velocity (V) $>$ wave velocity (v), the wave front changes

(a) from spherical to plane (b) from spherical to conical

(c) from plane to spherical (d) from cylindrical to spherical

29) If the average mass of a smoke particle in an Indian kitchen is 3×10^{-17} kg, the rms speed of the smoke particles at 27^0C is approximately

(a) 2 cm/sec (b) 2 m/sec (c) 2 km/sec (d) none of these

30) Two wires, made of same material, one thick and the other thin are joined to form one composite wire. The composite wire is subjected to the same tension throughout. A wave travels along the wire and passes the point where the two wires are joined. The quantity which changes at the joint are

(a) frequency only.

(b) propagation speed only.

(c) wavelength only.

(d) both propagation speed and wavelength.

31) The frequency of the third overtone of a closed end organ pipe equals the frequency of the fifth harmonic of an open end organ pipe. Ignoring end correction, the ratio of their lengths $l_{open} : l_{close}$ is

(a) 10:7 (b) 10:9 (c) 2:1 (d) 7:10

32) A concave mirror has a radius of curvature R and forms the image of an object placed at a distance $1.5R$ from the pole of the mirror. An opaque disc of diameter half the aperture of the mirror is placed with the pole at the centre. As a result

(a) the position of the image will be the same but its central half will disappear
(b) the position of the image will be the same but its outer half will disappear
(c) the complete image will be seen at the same position and it will be exactly identical with the initial image
(d) the complete image will be seen at the same position but it will not be identical in all respect with the initial image.

33) A ray of white light is made incident on the refracting surface of a prism such that after refraction at this surface, the green component falls on the second surface at its critical angle. The colours present in the emergent beam will be

(a) violet, indigo and blue.
(b) violet, indigo , blue, yellow, orange and red.
(c) yellow, orange and red.
(d) all colours

34) In a compound microscope, having tube-length 30 cm, the power of the objective and the eye-piece are100D and 10D respectively. Then the magnification produced by the microscope when the final image is at the least distance of distinct vision (25 cm) will be

(a) 55 (b) 64 (c) 77 (d) 90

35) Parallel rays are incident on a glass sphere of diameter 10 cm and having refractive index 1.5. The sphere converges these rays at a certain point. The distance of this point from the centre of the sphere will be

(a) 2.5 cm (b) 5 cm (c) 7.5 cm (d) 12.5 cm

36) A jet of water from 15 cm diameter nozzle of a fire hose can reach the maximum height of 25 m. The force exerted by the water jet on the hose is

(a) 4.24 kN (b) 17.32 kN (c) 2.17 kN (d) 8.66 kN

37) In an electromagnetic wave the phase difference between electric vector and magnetic vector is

(a) zero (b) $\frac{\pi}{2}$ (c) π (d) $\frac{3\pi}{2}$

38) A rectangular slab of glass of refractive index 1.5 is immersed in water of refractive index 1.33 such that the top surface of the slab remains parallel to water level. Light from a point source in air is incident on the surface of water at an angle α such that the light reflected from the glass slab is plane polarised, the angle α is

(a) 84.4° (b) 48.4° (c) 56.3° (d) 53.1°

39) In a spectrometer the smallest main scale division is $\frac{1}{3}$ of a degree. The total number of divisions on the vernier scale attached to the main scale is 60 which coincide with the 59 divisions of the main circular scale. The least count of the spectrometer is

(a) 20' (b) 20" (c) 30" (d) 30'

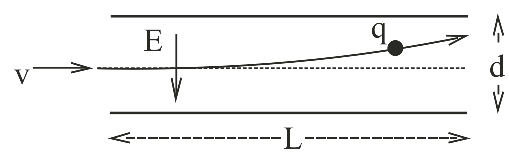
40) White light is used to illuminate two slits in Young's double sit experiment. Separation between the two slits is b and the screen is at a distance D (>>b) from the plane of slits. The wavelength missing at a point on the screen directly in front of one of the slits is

(a) $\frac{2b^2}{3D}$ (b) $\frac{2b^2}{D}$ (c) $\frac{b^2}{3D}$ (d) $\frac{b^2}{2D}$

41) In an ink-jet printer, an ink droplet of mass m is given a negative charge q by a computer-controlled charging unit. The charged droplet then enters the region between two deflecting parallel plates of length L separated by distance d (see figure below) with a speed v. All over this region there exists a uniform downward electric field E (in the plane of paper). Neglecting the gravitational force on the droplet, the maximum charge that can be given to this droplet, so that it does not hit any of the plates, is

(a) $\frac{mv^2L}{Ed^2}$ (b) $\frac{mv^2d}{EL^2}$

(c) $\frac{md}{Ev^2L^2}$ (d) $\frac{mv^2L^2}{Ed}$



42) A converging beam of light is pointing to P. Two observations are made with (i) a convex lens of focal length 20 cm and,(ii) a concave lens of focal length 16 cm placed in the path of the convergent beam at a distance 12 cm before the point P. It is observed that

(a) in both cases the images are real.
(b) in both cases the images are virtual.
(c) for (i) the image is real and for (ii) the image is virtual.
(d) for (i) the image is virtual and for (ii) the image is real.

43) A spherical capacitor is formed by two concentric metallic spherical shells. The capacitor is then charged so that the outer shell carries a positive charge and the inner shell carries an equal but negative charge. Even if the capacitor is not connected to any circuit, the charge will eventually leak away due to a small electrical conductivity of the material between the shells. What is the character of the magnetic field produced by this leakage current?

(a) Radially outwards from the inner shell to the outer shell.

(b) Radially inwards from the outer shell to the inner shell.

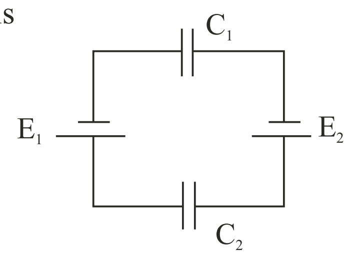
(c) Circular field lines between the shells and perpendicular to the radial direction.

(d) No magnetic field will be produced.

44) If a cell of constant emf produces the same amount of heat during the same time in two independent resistors R_1 and R_2 when they are separately connected across the terminals of the cell, one after the other. The internal resistance of the cell is

(a) $\frac{R_1+R_2}{2}$ (b) $\frac{R_1 \sim R_2}{2}$ (c) $\frac{\sqrt{R_1^2+R_2^2}}{2}$ (d) $\sqrt{R_1 R_2}$

45) In the circuit shown beside the charge on each capacitor is



(a) $(C_1+C_2)(E_1-E_2)$ (b) $\frac{C_1C_2}{C_1+C_2}(E_1+E_2)$

(c) $\frac{C_1C_2}{C_1+C_2}(E_1-E_2)$ (d) $(C_1-C_2)(E_1+E_2)$

46) A stationary hydrogen atom emits photon corresponding to the first line (highest wave length) of Lyman series. If R is the Rydberg constant and M is the mass of the atom, the recoil velocity of the atom is

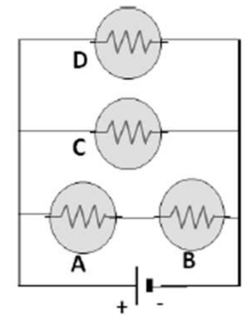
(a) $\frac{Rh}{4M}$ (b) $\frac{3Rh}{M}$ (c) $\frac{3Rh}{4M}$ (d) $\frac{Rh}{M}$

47) Heat is absorbed or evolved when current flows in a conductor having a temperature gradient. This phenomenon is known as

(a) Joule effect (b) Peltier effect

(c) Seeback effect (d) Thomson effect

48) Identify the rank in order from the dimmest to the brightest when all the identical bulbs are connected in the circuit as shown below.



(a) A=B > C=D

(b) A=B = C=D

(c) A>C > B>D

(d) A=B < C=D

49) The unit of magnetizing field is

(a) tesla (b) newton (c) ampere (d) ampere turn/meter

50) A star undergoes a supernova explosion. Just after the explosion, the material left behind forms a uniform sphere of radius 8000 km with a rotation period of 15 hours. This remaining material eventually collapses into a neutron star of radius 4 km with a period of rotation

(a) 14 s (b) 3.8 h (c) 0.021 s (d) 0.0135 s

51) A number of identical absorbing plates are arranged in between a source of light and a photo cell. When there is no plate in between, the photo current is maximum. Under the circumstances let us focus on the two statements -

(1) The photo current decreases with the increase in number of absorbing plates.

(2) The stopping potential increases with the increase in number of absorbing plates.

(a) Statements (1) and (2) are both true and (1) is the cause of (2).

(b) Statements (1) and (2) are both true but (1) and (2) are independent.

(c) Statement (1) is true while (2) is not true and (1) and (2) are independent.

(d) Statement (1) is true while (2) is not true and (2) is the effect of (1).

52) In a nuclear reaction, two photons each of energy 0.51 MeV are produced by electron-positron annihilation. The wavelength associated with each photon is

(a) 2.44×10^{-12}m (b) 2.44×10^{-8}m (c) 1.46×10^{-12}m (d) 3.44×10^{-10}m

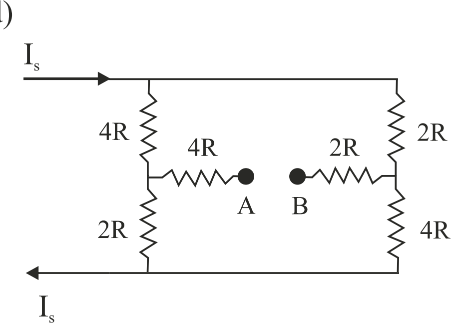
53) In the circuit shown if an ideal ammeter is connected between A and B then the direction of current and the current reading would be (assume I_s remains unchanged)

(a) B to A and $I_s/2$

(b) A to B and $I_s/4$

(c) B to A and $I_s/9$

(d) B to A and $I_s/3$



54) Avalanche breakdown in a p-n junction primarily depends on the phenomenon of

(a) doping (b) collision (c) recombination (d) ionization

55) A source emits photons of energy 5 eV which are incident on a metallic sphere of work function 3.0 eV. The radius of the sphere is r = 8 x 10^{-3} m. It is observed that after some time emission of photoelectrons from the metallic sphere is stopped. Charge on the sphere when the photoemission stops is.

(a) 1.77×10^{-16} C (b) 1.77×10^{-12} C (c) 1.11×10^{-12} C (d) 1.11×10^{-10} C

56) The dc component of current in the output of a half-wave rectifier with peak value I_o is

(a) zero (b) $\frac{I_0}{\pi}$ (c) $\frac{I_0}{2\pi}$ (d) $\frac{2I_0}{\pi}$

57) In an experiment on photoelectric effect, the slope of straight line graph between the stopping potential and the frequency of incident radiation gives

(a) Electron charge (e) (b) Planck constant (h)

(c) $\frac{h}{e}$ (d) Work function (W)

58) According to Bohr's theory the ionization energy of H atom is 13.6 eV. The energy needed to remove an electron from Helium ion (He^+) is

(a) 13.6 eV (b) 16.8 eV (c) 27.2 eV (d) 54.4 eV

59) The phenomenon inverse to photo electric effect is

(a) Compton effect (b) Pair production

(c) Raman effect (d) Production of X-rays in Coolidge tube

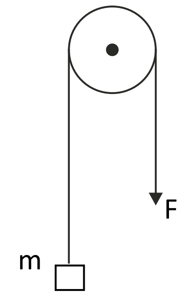
60) A stationary hydrogen atom emits a photon of wavelength 1025 Å. Its angular momentum changes by

(a) $\frac{h}{\pi}$ (b) $\frac{2h}{\pi}$ (c) $\frac{h}{2\pi}$ (d) $\frac{3h}{2\pi}$

A - 2

ANY NUMBER OF OPTIONS 4, 3, 2 or 1 MAY BE CORRECT

61) A block of mass m = 10 kg is hanging over a frictionless light fixed pulley by an inextensible light rope. Initially the block is held at rest. The other end of the rope is now pulled by a constant force F in the vertically downward direction. The linear momentum of the block is seen to increase by 2 kgm/s in 1 s (in the first second). Therefore,



(a) the tension in the rope is F

(b) the tension in the rope is 3N

(c) the work done by the tension on the block, in first second, is = 19.8 J

(d) the work done against the force of gravity, in first second, is = 9.8 J

62) A ball of mass m_1 travels horizontally along the x-axis in the positive direction with an initial speed of v_0. It collides with another ball of mass m_2 that is originally at rest. After the collision, the ball of mass m_1 has velocity $(v_{1x}\hat{i}+v_{1y}\hat{j})$ and the ball of mass m_2 has velocity $(v_{2x}\hat{i}+v_{2y}\hat{j})$. Identify the correct relationship(s)

(a) $0=m_1v_{1x}+m_2v_{2x}$ (b) $m_1v_0=m_1v_{1y}+m_2v_{2y}$

(c) $0=m_1v_{1y}+m_2v_{2y}$ (d) $m_1v_0=m_1v_{1x}+m_2v_{2x}$

63) In a real gas

(a) the force of attraction between the molecules depends upon intermolecular distance.

(b) internal energy depends only upon temperature.

(c) internal energy is a function of both temperature and volume.

(d) internal energy is a function of both temperature and pressure.

64) A particle of mass m is thrown vertically up with velocity u. Air exerts an opposing force of a constant magnitude F. The particle returns back to the point of projection with velocity v after attaining maximum height h, then

(a) $h=\dfrac{u^2}{2\left(g+\dfrac{F}{m}\right)}$ (b) $h=\dfrac{v^2}{2\left(g-\dfrac{F}{m}\right)}$

(c) $v=u\sqrt{\dfrac{\left(g-\dfrac{F}{m}\right)}{\left(g+\dfrac{F}{m}\right)}}$ (d) $v=u\sqrt{\dfrac{\left(g+\dfrac{F}{m}\right)}{\left(g-\dfrac{F}{m}\right)}}$

65) A pin of small length 'a' is placed along the axis of a concave mirror of focal length f, at the distance u (> f) from its pole. The length of its image is 'b'. If the same object is placed perpendicular to its axis at the same distance u and the length of its image is now 'c', then

(a) $b = a\dfrac{f^2}{(u-f)^2}$ (b) $c = \sqrt{ab}$ (c) $c = b\dfrac{u-f}{f}$ (d) $bc = \dfrac{a^2 f^3}{(u-f)^3}$

66) A thin rod of length 10 cm. is placed along the axis of a concave mirror of focal length 30 cm in such a way that one end of the image coincides with one end of the object. The length of the image may be

(a) 7.5 cm (b) 12 cm (c) 15 cm (d) 10 cm

67) The mass of an electron can be expressed as

(a) 0.512 MeV (b) 8.19×10^{-14} J / c^2 (c) 9.1×10^{-31} kg (d) 0.00055 amu

where c is speed of light in vacuum

68) Select the correct statement(s), out of the following, about diffraction at N parallel slits.

(a) There are (N-1) minima between each pair of principal maxima.

(b) There are (N-2) secondary maxima between each pair of principal maxima.

(c) Width of principal maximum is proportional to 1/N.

(d) The intensity at the principal maxima varies as N^2.

69) An electric dipole placed in a non-uniform electric field may experience

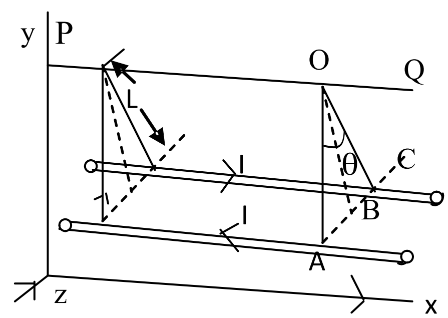
(a) no net force, no torque. (b) a net force, but no torque.

(c) no net force, but a torque. (d) a net force and a torque.

70) Two long parallel wires carry currents of equal magnitude (I) but in opposite directions. These wires are suspended from fixed rod PQ by four chords of equal length L as shown. The mass per unit length of each wire is λ , the value of angle θ substended by two chords OA and OB, assuming it to be small, is

(a) $\theta = I\sqrt{\dfrac{\mu_0}{4\pi}\dfrac{\lambda}{gL}}$ (b) $\theta = I\sqrt{\dfrac{\mu_0}{\pi}\dfrac{1}{\lambda gL}}$

(c) $\theta = I\sqrt{\dfrac{\mu_0}{4\pi}\dfrac{g}{\lambda L}}$ (d) $\theta = I\sqrt{\dfrac{\mu_0}{\pi}\dfrac{\lambda g}{L}}$



Rough Work

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS 2015-16

Date of Examination: 22nd November, 2015

Time: 0930 to 1130 Hrs

Q. Paper Code: P 105

Write the question paper code mentioned above on YOUR answer sheet (in the space provided), otherwise your answer sheet will NOT be assessed. Note that the same Q. P. Code appears on each page of the question paper.

Instructions to Candidates –

1. Use of mobile phones, smartphones, ipads during examination is **STRICTLY PROHIBITED**.
2. In addition to this question paper, you are given answer sheet along with Candidate's copy.
3. On the answer sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/carelessly filled information may disqualify your candidature.
4. On the answer sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Question paper has two parts. In Part A1(Q. Nos 1 to 60) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   Q. No. 22 (a) ● (c) (d)

   In Part A2 (Q. Nos. 61 to 70) each question has four alternatives out of which **any number of alternatives** (1, 2, 3 or 4) may be correct. You have to choose ALL correct alternatives and fill the appropriate bubbles, as shown.

   Q. No. 64 (a) ● (c) ●

6. For **Part A1**, each correct answer gets 3 marks. A wrong one gets a penalty of 1 mark. **Part A2** full marks are 6 for each question, you get them when **ALL** correct answers are marked.
7. Any rough work should be done only in the space provided.
8. Use of **non-programmable** calculator is allowed.
9. No candidate should leave the examination hall before the completion of the examination.
10. After submitting your answerpaper, take away the Candidate's copy for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the answer sheet.

Answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED.

Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (continued)–

Read the following instructions after submitting the answer sheet.

11. **Comments regarding this question paper, if any, may be sent by email only to iaptpune@gmail.com till 24th November, 2015.**
12. **The answers/solutions to this question paper will be available on our website – www.iapt.org.in by 2nd December, 2015.**
13. **CERTIFICATES and AWARDS –**

    Following certificates are awarded by the IAPT to students successful in NSEs

    (i)Certificates to "Centre Top 10%" students

    (ii)Merit Certificates to "Statewise Top 1%" students

    (iii)Merit Certificates and a book prize to "National Top 1%" students
14. Result sheets and the "Centre Top 10%" certificates will be dispatched to the Prof-in-charge of the centre by January, 2016.
15. List of students (with centre number and roll number only) having score above MAS will be displayed on our website (**www.iapt.org.in**) by **22nd December, 2015.** See the **Eligibility Clause** in the Student's brochure on our website.
16. Students eligible for the INO Examination on the basis of selection criteria mentioned in Student's brochure will be informed accordingly.
17. Gold medals will be awarded to TOP 35 students in the entire process.

Instructions to Candidates (continued)–

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Q.P. Code –P 105

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2015-16

Total Time : 120 minutes (A-1 and A-2)

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT.

N. B. – Physical constants are given at the end.

1. An expression containing certain physical quantities is (1273.43 – 51.7052 + 745)× 21. After evaluation the correct answer is

   (a) 41301.2208 (b) 4.1×10^4 (c) 41307 (d) 41000

2. A body of mass *m* and radius *R* rolling horizontally without slipping at a speed *v* climbs a ramp to a height $\frac{3v^2}{4g}$. The rolling body can be

   (a) a sphere (b) a circular ring (c) a spherical shell (d) a circular disc

3. A particle of mass 10 g starts from rest at *t* = 0 s from a point (0 m, 4 m) and gets accelerated at 0.5 m/s^2 along $x - \sqrt{3}y + 4\sqrt{3} = 0$ in XY plane. The angular momentum of the particle about the origin (in SI units) at *t* = 2 s is

   (a) $-0.01\sqrt{3}\,\hat{k}$ (b) $-0.02\sqrt{3}\,\hat{k}$ (c) zero (d) $-20\sqrt{3}\,\hat{k}$

4. A body released from a height *H* hits elastically an inclined plane at a point P. After the impact the body starts moving horizontally and hits the ground. The height at which point P should be situated so as to have the total time of travel maximum is

   (a) *H* (b) 2 *H* (c) $\frac{H}{4}$ (d) $\frac{H}{2}$

5. A thin rod of length *l* in the shape of a semicircle is pivoted at one of its ends such that it is free to oscillate in its own plane. The frequency *f* of small oscillations of the semicircular rod is

   (a) $\frac{1}{2\pi}\sqrt{\frac{g\pi}{2l}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{g\sqrt{\pi^2+4}}{2l}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{g(\pi+2)}{l}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{g(\pi^2+1)}{2\pi l}}$

6. Two air bubbles with radii r_1 and r_2 ($r_2>r_1$) formed of the same liquid stick to each other to form a common interface. Therefore, the radius of curvature of the common surface is

(a) $\sqrt{r_1 r_2}$ (b) infinity (c) $\frac{r_2}{r_1}\sqrt{r_2^2 - r_1^2}$ (d) $\frac{r_1 r_2}{r_2 - r_1}$

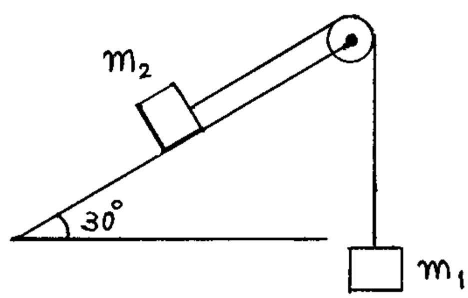
7. A particle executes a periodic motion according to the relation $x = 4\cos^2(50t)\sin(500t)$. Therefore, the motion can be considered to be the superposition of n independent simple harmonic motions, where n is

(a) 2 (b) 3 (c) 4 (d) 5

8. A car moving along a straight road at a speed of u m/s applies brakes at $t = 0$ second. The ratio of distances travelled by the car during 3rd and 8th secondis 15 : 13. The car covers a distance of 0.25 m in the last second of its travel. Therefore, the acceleration a(in m/s^2) and the speed u(in m/s) of the car are respectively

(a) −0.1, 16 (b) −0.2, 12 (c) −0.5, 20 (d) −0.1 , 16

9. Masses m_1 and m_2 are connected to a string passing over a pulley as shown. Mass m_1 starts from rest and falls through a distance d in time t. Now, by interchanging the massesthe time required for $m_2$to fall through the same distance is 2 t. Therefore, the ratio of masses m_1 : m_2 is



(a) $\frac{2}{3}$ (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) $\frac{4}{3}$

10. The graph of specific heat of water (on Y axis) against temperature (on X axis) between 0° C and 100° C

(a) is a straight line parallel to the temperature axis.
(b) is a straight line passing through a point (15° C, 1 cal/g-$^\circ$C) and having a small positive slope.
(c) has a minimum between 14.5° C and 15.5° C.
(d) has a minimum at about 30° C.

11. When a light wave is incident at the interface between two media, the reflection coefficient is given by $\frac{(n-1)^2}{(n+1)^2}$ where n is the refractive index of the denser medium with respect to the rarer medium. Two stretched strings whose linear densities are 25 g/m and 9 g/m are joined together. Assuming the law of optics holds good here also, the reflection coefficient for the pulse along the strings is

(a) $\frac{9}{16}$ (b) $\frac{3}{4}$ (c) $\frac{1}{16}$ (d) $\frac{1}{9}$

12. A certain perfect gas occupying 1 litre at 80 cm of Hg suddenly expands to 1190 cc while the pressure falls to 60 cm of Hg. Therefore, the gas is

(a) polyatomic (b) diatomic (c) monatomic (d) data inadequate

13. Two thin rods of lengths l_1 and $l_2$at a certain temperature are joined to each other end to end. The composite rod is then heated through a temperature θ. The coefficients of linear expansion of the two rods are α_1 and α_2 respectively. Then, the effective coefficient of linear expansion of the composite rod is

(a) $\frac{\alpha_1+\alpha_2}{2}$ (b) $\sqrt{\alpha_1\alpha_2}$ (c) $\frac{l_1\alpha_2+l_2\alpha_1}{l_1+l_2}$ (d) $\frac{l_1\alpha_1+l_2\alpha_2}{l_1+l_2}$

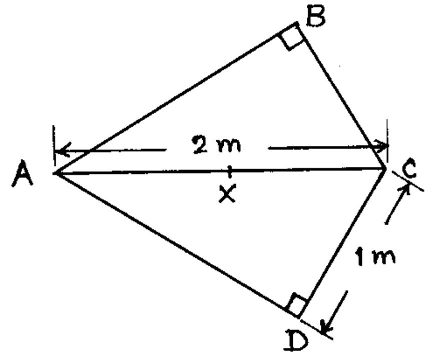
14. A yo-yo has a spool of mass m and radius R. A massless string is wound around an axle of radius b and of negligible mass. If the yo-yo released from rest has a downward acceleration of $\frac{g}{9}$, the ratio $\frac{R}{b}$ is

(a) 2 (b) 3 (c) 4 (d) 5

15. A pulley of negligible mass is suspended from a spring balance. Blocks weighing 5.0 kg and 3.0 kg are attached to the two ends of a string passing over the pulley. The reading on the spring balance will be

(a) 8.0 kg (b) 7.5 kg (c) 2.0 kg (d) 4.0 kg

16. A uniform rod (ABCDAC) is bent in the shape of a kite as shown. If a point X along AC is the centre of mass of the structure, distance AX is



(a) 1.50 m (b) 1.08 m (c) 1.00 m (d) 1.10 m

17. Two particles, each of mass m and charge q are attached at the ends of a light rod of length $2r$. The rod is rotated at a constant angular speed ω about an axis perpendicular to the rod passing through its centre. The ratio of magnetic moment of the system to its angular momentum is

(a) $\frac{q}{m}$ (b) $\frac{q}{2m}$ (c) $\frac{2q}{m}$ (d) $\frac{q}{4m}$

18. A jet of water of cross-sectional area A hits a plate normally with velocity v. The plate is moving in the direction of the jet with velocity V. Therefore, the force exerted on the plate is proportional to

(a) v (b) v^2 (c) $(v-V)$ (d) $(v-V)^2$

19. A heavy cylindrical shaft (pile) of mass M is driven vertically through a distance s into the ground by the blow of a pile-driver of mass m. The pile driver drops vertically through a distance h onto the head of the pile. The average resistance of the ground is

(a) $g\left[\frac{m^2}{M}\frac{h}{s}+2m\right]$

(b) $g\left[\frac{m^2}{(m+M)}\frac{h}{s}+(m+M)\right]$

(c) $g\left[\frac{M^2}{m}\frac{h}{s}+(m+M)\right]$

(d) $g\left[\frac{m^2}{(m+M)}\frac{h}{s}+2(m+M)\right]$

20. An optical fibre consists of a core (refractive index n_1) surrounded by a cladding (refractive index n_2). A ray of light enters the fibre from air at an angle θ with the fibre axis. The maximum value of θ for which the ray can propagate down the fibre is

(a) $sin^{-1}\sqrt{\frac{n_1}{n_2}}$ (b) $sin^{-1}\sqrt{\frac{n_2}{n_1}}$ (c) $sin^{-1}\sqrt{n_1^2+n_2^2}$ (d) $sin^{-1}\sqrt{n_1^2-n_2^2}$

21. Two coils wound on the same magnetic core have inductances L_1 and L_2. When the two coils are connected in series, the effective inductance is

(a) $L_1 + L_2$.
(b) certainly greater than $L_1 + L_2$.
(c) certainly less than $L_1 + L_2$.
(d) none of the above.

22. A particle of mass m and charge $-q$ moves along a diameter of a uniform spherical charge distribution of radius R with total charge $+Q$. The angular frequency of the periodic motion performed by the particle is

(a) $\sqrt{\frac{2\pi}{\epsilon_0}\frac{qQ}{mR^3}}$ (b) $\sqrt{\frac{1}{2\pi\epsilon_0}\frac{qQ}{mR^3}}$ (c) $\sqrt{\frac{1}{\epsilon_0}\frac{qQ}{mr^3}}$ (d) $\sqrt{\frac{1}{4\pi\epsilon_0}\frac{qQ}{mR^3}}$

23. A spherical body of mass m_1 moving with a speed $u_1$collides elastically with a lighter spherical body of mass m_2 initially at rest. The maximum angle through which the heavier body gets deflected after collision depends upon

(a) $m_1$and $u_1$only (b) $m_2$and u_1 only (c) m_1 and m_2 only (d) m_1, m_2 and u_1 all

24. A non-conducting spherical shell of radius R surrounds a point charge q. The electric flux through a cap of the shell of half angle θ is

(a) $\frac{2\pi q\theta}{\epsilon_0}$. (b) $\frac{q}{2\epsilon_0}(1-cos\theta)$. (c) $\frac{q(2\theta)}{4\pi\epsilon_0}$. (d) $\frac{q\theta}{2\pi\epsilon_0}$.

25. In a Young's double slit experiment the intensity at a point is I where the corresponding path difference is one sixth of the wavelength of light used. If I_0 denotes the maximum intensity, the ratio $\frac{I}{I_0}$ is equal to

(a) $\frac{1}{4}$ (b)$\frac{1}{2}$ (c)$\frac{\sqrt{3}}{2}$ (d)$\frac{3}{4}$

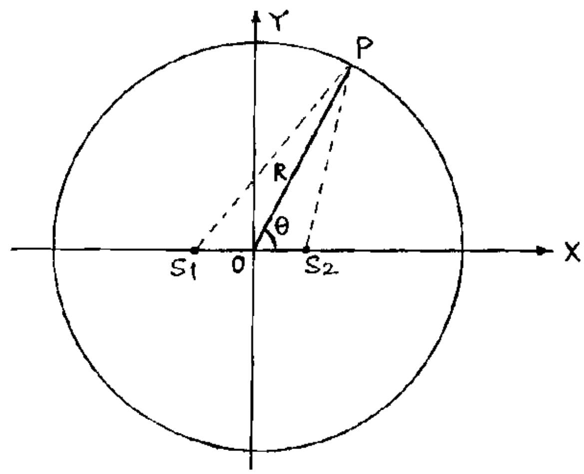
26. A charge $+q$is placed at a distance of d from a point O. A conducting body surrounds point O such that q remains outside. The electric field at O due to the induced charge is

(a) zero
(b) $\frac{1}{4\pi\epsilon_0}\frac{q}{d^2}$directed towards the charge q
(c) $\frac{1}{4\pi\epsilon_0}\frac{q}{d^2}$ directed away from the charge q
(d) data insufficient

27. A coaxial cable consists of two thin cylindrical conducting shells of radii a and$b$ ($a<b$). The inductance per unit length of the cable is

(a) $\frac{\mu_0}{2\pi}\frac{(a+b)}{a}$ (b) $\frac{\mu_0}{4\pi}ln\left(\frac{a}{b}\right)$ (c) $\frac{\mu_0}{4\pi}ln\left(\frac{b}{a}\right)$ (d) $\frac{\mu_0}{2\pi}ln\left(\frac{b}{a}\right)$

28. Two coherent sources of light S_1 and S_2, equidistant from the origin, are separated by a distance 2λ as shown. They emit light of wavelength λ. Interference is observed on a screen placed along the circle of large radius R. Point P is seen to be a point of constructive interference. Then, angle θ (other than 0^o and 90^o) is



(a) 45^o (b) 30^o (c) 60^o (d) not possible in the first quadrant

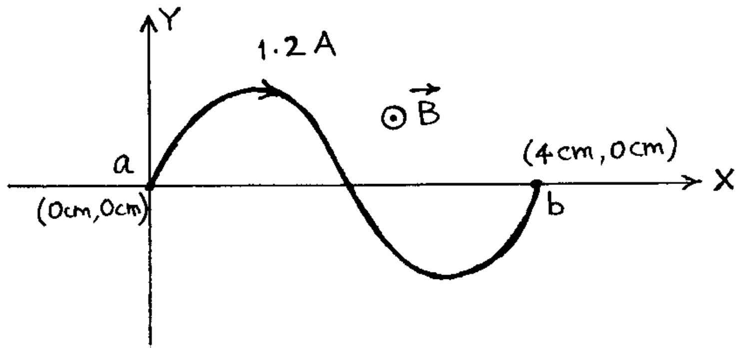
29. If a current of 2 A passing through a certain electrolyte for t minutes liberates 1 gram of oxygen, then t is about

(a) 6000 (b) 100 (c) 50 (d) 25

30. A polarized light is incident on a polaroid. Let I_0 be the intensity of light transmitted by this polaroid. Now, a very large number (say N) of polaroids is placed in a row with their axes displaced through a small angle θ successively. If the last polaroid is crossed to the first one, the intensity of light transmitted by the last polaroid is about

(a) zero (b)$\frac{I_0}{2}$ (c)I_0 (d) $\frac{I_0}{N}$

31. A wire *ab* of length 10 cm is fixed in the shape of a sinusoidal curve as shown. The wire carries a current of 1.2 A. In a uniform magnetic field $\vec{B}$ of 0.1 T, the wire experiences a force whose magnitude is



(a) 1.2×10^{-2}N. (b) 4.8×10^{-3}N. (c) zero. (d) insufficient data.

32. A charge $(-2Q)$ is distributed uniformly on a spherical balloon of radius R. Another point charge $(+Q)$ is situated at the centre of the balloon. The balloon is now inflated to twice the radius. Neglecting the elastic energy involved in the process, the change in total electric energy of the system is

(a) $\frac{-Q^2}{2\pi\epsilon_0 R}$ (b) $\frac{-Q^2}{4\pi\epsilon_0 R}$ (c) $\frac{+Q^2}{4\pi\epsilon_0 R}$ (d) zero

33. A rainbow is formed when a ray of sunlight passes through a spherical raindrop. Then the total angle through which the ray deviates is (i and r denote the angles of incidence and of refraction respectively)

(a) $2i - 4r$ (b) $\pi + 2i - 4r$ (c) $2(i - r)$ (d) $2(\pi + i - 2r)$

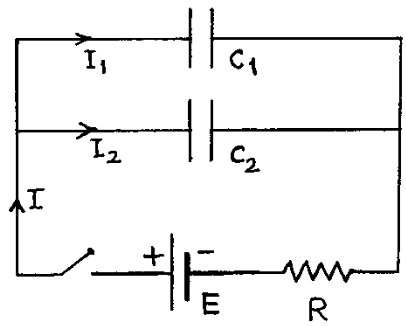
34. A series LCR circuit is connected to an ac source of frequency f and a voltage V. At this frequency, reactance of the capacitor is 350 ohm while the resistance of the circuit is 180 ohm. Current in the circuit leads the voltage by 54° and power dissipated in the circuit is 140 watt. Therefore, voltage V is

(a) 250 volt (b) 260 volt (c) 270 volt (d) 280 volt

35. A car has a rear view mirror of focal length 20 cm. A truck 2 m broad and 1.6 m in height is overtaking the car with a relative speed of 15 km/hr. At the moment when the truck is 6 m behind the car, the car driver will see the image of the truck to be moving at a speed of

(a) 0.0043 m/s (b) 0.13 m/s (c) 0.21 m/s (d) 4.17 m/s

36. In the circuit shown below the switch is closed at $t = 0$. For $0 < t < R\,(C_1 + C_2)$, the current I_1 in the capacitor C_1 in terms of total current I is



(a) $\left(\frac{C_1}{C_2}\right)I$ (b) $\left(\frac{C_2}{C_1}\right)I$ (c) $\left(\frac{C_1}{C_1+C_2}\right)I$ (d) $\left(\frac{C_2}{C_1+C_2}\right)I$

37. The earth is getting energy from the sun whose surface temperature is T_s and radius is R. Let the radius of the earth be r and the distance from the sun be d. Assume the earth and the sun both to behave as perfect black bodies and the earth is in thermal equilibrium at a constant temperature T_e. Therefore, the temperature $T_s$of the sun is xT_e where x is

(a) $\sqrt{\frac{2d}{R}}$ (b) $\sqrt{\frac{2R}{r}}$ (c) $\sqrt{\frac{4d}{r}}$ (d) $\frac{d}{R}$

38. Imagine an atom made up of a proton and a hypothetical particle of double the mass as that of an electron but the same charge. Apply Bohr theory to consider transitions of the hypothetical particle to the ground state. Then, the longest wavelength (in terms of Rydberg constant for hydrogen atom) is

(a) $\frac{1}{2R}$ (b) $\frac{5}{3R}$ (c) $\frac{1}{3R}$ (d) $\frac{2}{3R}$

39. The half life period of a radioactive element X is the same as the mean lifetime of another radioactive element Y. Initially both of them have the same number of atoms. Then,

(a) X and Y have the same initial decay rate.
(b) X and Y decay at the same rate always.
(c) Y will decay at larger rate than X.
(d) X will decay at larger rate than Y.

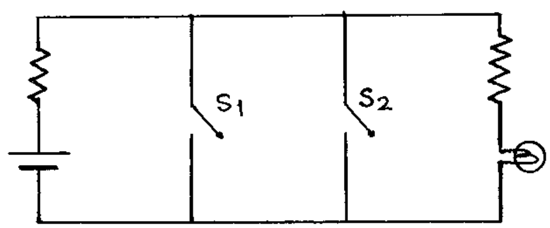
40. A sodium atom emits a photon of wavelength 590 nm and recoils with velocity v equal to

(a) 0.029 m/s (b) 0.048 m/s (c) 0.0023 m/s (d) data inadequate

41. A practical diode (p-n junction) when forward biased is equivalent to

    (a) a closed switch.
    (b) a cell (potential difference).
    (c) a small resistance.
    (d) all the above in series.

42. The circuit shown below is equivalent to



    (a) OR gate (b) NOR gate (c) AND gate (d) NAND gate

43. Which one of the following statements in connection with a semiconducting material is NOT CORRECT?

    (a) They have negative temperature coefficient of resistance.
    (b) They have a moderate forbidden energy gap.
    (c) Current is carried by electrons and holes both.
    (d) Every semiconducting material is a tetravalent element.

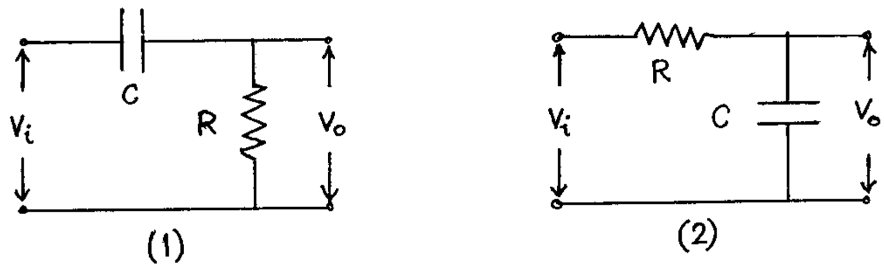
Group of Q. Nos. 44 to 51 is based on the following paragraph.

Generally light emitted from a source contains several wavelengths. Similarly the electrical voltage at the output of a sensor contains a mixture of dc and several ac components of different amplitudes and different frequencies. Filter circuits are used to pass desired frequencies and /or to eliminate undesired frequencies. The frequencies transmitted by the filter form the pass band while the frequencies eliminated by the filter form the stop band or rejection band.

We can think of four basic types of electrical filters- a low pass filter where frequencies below a certain cutoff frequency $f_c$are passed. Similarly one can think of a high pass filter, band pass filter, band stop (or band rejection) filter. The cutoff frequency f_c is the frequency at which the output voltage falls to $\frac{1}{\sqrt{2}}$ times its maximum value.

An inductor and/or a capacitoris an essential component of a filter. Generally a resistance is included in a filter circuit to determine the time constant and hence the cutoff frequency.

44. Refer to the RC networks (1) and (2) shown below. Which of the following statements is true?



(a) Each of the two networks represents a low pass filter.
(b) Each of the two networks represents a high pass filter.
(c) Network (1) represents a low pass filter while network (2) a high pass filter.
(d) Network (1) represents a high pass filter while network (2) a low pass filter.

45. The input-output voltage relation for a certain high pass filter is given by

$$\frac{V_o}{V_i} = \frac{\omega CR}{\sqrt{1+\omega^2C^2R^2}}$$

The cut-off frequency(f_c) for this filter will be

(a) $\frac{1}{2\pi RC}$ (b) $\frac{\sqrt{2}}{\pi RC}$ (c) $\frac{\pi}{2RC}$ (d) $\frac{1}{RC}$

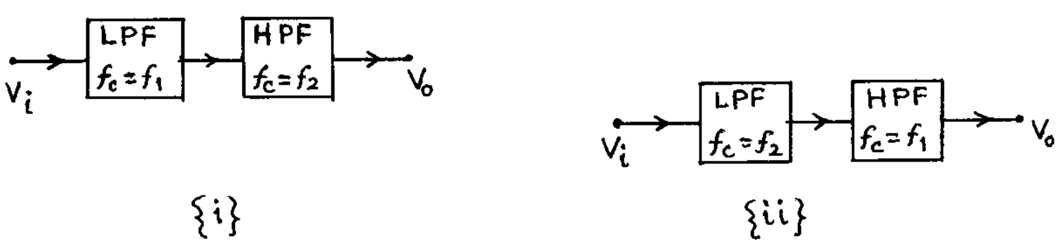
46. The input-output voltage relation for a certain filter circuit is given by

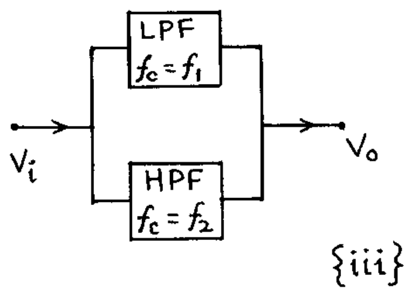
$$\frac{V_o}{V_i} = \frac{\omega\beta A}{\sqrt{(\omega_1^2-\omega^2)^2+\omega^2\beta^2}}$$

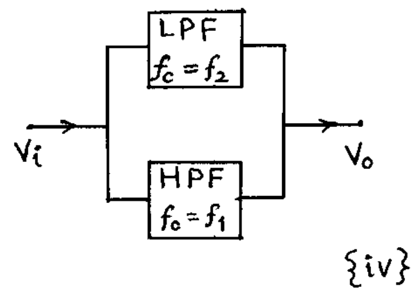
where ω is the angular frequency of the input while ω_1, A and β are constants. This relation is meant for

(a) low pass filter (b) high pass filter (c) band pass filter (d) band stop filter

47. Refer to the following schematic diagrams of different combinations of a low pass filter (LPF) and a high pass filter (HPF). Assume $f_1 < f_2$. The combination that works as a band pass filter is







(a) {i} (b) {ii} (c) {iii} (d){iv}

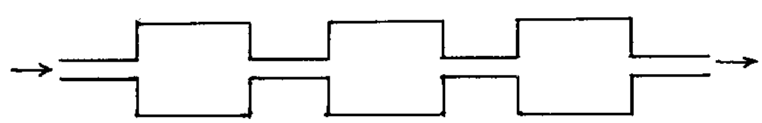
48. Refer to the schematic diagram in Q. No. (47). The combination that works as a band elimination filter is

(a) {i} (b) {ii} (c) {iii} (d) {iv}

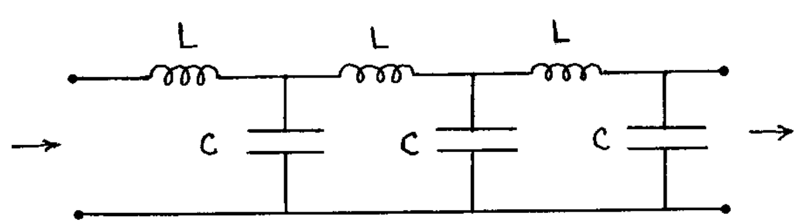
49. An astrophysicist desires to study radiation at wavelengths higher than those for visible light coming from a certain celestial body. He must use an optical filter that is

(a) high pass. (b) low pass. (c) band pas (d) band rejection

50. Figure (A) below shows an acoustical filter that consists of a set of identical cavities connected by narrow tubes and figure (B) shows its electrical analog. The acoustical filter represented by figure (A) is



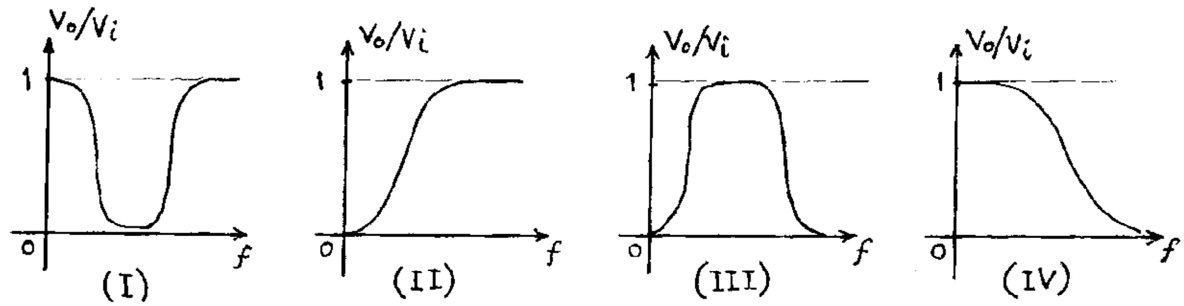
(A)



(B)

(a) low pass (b) high pass (c) band pass (d) band rejection

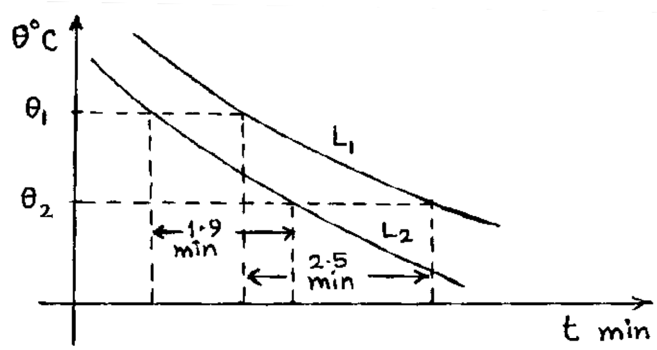
51. Graphs I, II, III and IV shown below represent the frequency response of different types of filter circuits. The correct order of these graphs corresponding to low pass, high pass, band pass and band stop filter is



(a) I, II, III, IV (b) II, IV, III, I (c) IV, II, III, I (d) IV, III, II, I

Group of Q. Nos. 52 to 60isbased on the following paragraph.

Equal volumes of two liquids (L_1 and L_2) are taken in two identical calorimeters. Both L_1 and L_2 are initially at about 80^oC. Calorimeters are corked fitted with thermometers to record the temperatures of the liquids. The temperatures are recorded every 30 s alternating between the two liquids, that is the temperatures are recorded at an interval of 1 min for any one liquid. The graphs of temperature θ (^oC) versus time t (min)for two liquids L_1 and $L_2$are as shown.



52. From the graphs it can be said that

(a) Newton's law of cooling is not valid.
(b) thespecific heat of L_2 is greater than that of L_1.
(c) the observations recorded are not consistent.
(d) none of the above statements is correct.

53. Equal volumes of the two liquids are necessary so that
(a) heat contents of the two liquids are equal.
(b) the exposed surfaces are equal.
(c) thecalculations are simplified.
(d) none of the above.

54. The nature of the outer surfaces of the calorimeters

(a) should be blackened and rough.
(b) should be silvered and rough.
(c) should be silvered and polished / shining.
(d) could be arbitrary.

55. Which of the following arrangements would be the ideal environment for the two calorimeters?

(a) A double walled box, both inner and outer space filled with water.
(b) A double walled box with water in the inner box and empty outer box.
(c) A double walled box with water in the outer box and empty inner box.
(d) In air without any box.

56. The two curves will
(a) intersect at some later time.
(b) merge after a long time.
(c) remain separate at all times.
(d) be parallel to the X axis but distinct after a long time.

57. Given: mass of L_1 = 50 g and mass of L_2 = 62.5 g. If water equivalent of calorimeters is assumed to be negligible, then $\left(\frac{s_1}{s_2}\right)$equals

(a) 1.04 (b) 0.60 (c) 0.95 (d) 1.64

58. If $\rho_1$and ρ_2 are the densities of L_1 and L_2 respectively then, identify the correct statement.

(a) $s_1>s_2$, $\rho_1>\rho_2$
(b) $s_1>s_2$, $\rho_1<\rho_2$
(c) $s_1<s_2$, $\rho_1>\rho_2$
(d) $s_1<s_2$, $\rho_1<\rho_2$

59. If the experiment is carried out with equal masses of the two liquids, then

(a) L_1 will cool faster.
(b) L_2 will cool faster.
(c) both the liquids will cool at the same rate.
(d) nothing can be said about the rates as data are insufficient.

60. The entire experiment is repeated with other two liquids having nearly the same specific heats. Then,

(a) the two curves will be coincident.
(b) the two curves will be parallel.
(c) the two curves will intersect at a point.
(d) nothing can be said about the two curves as data are insufficient.

A 2

In Q. Nos. 61 to 70 any number of options (1 or 2 or 3 or all 4) may be correct. You are to identify all of them correctly to get 6 marks. Even if one answer identified is incorrect or one correct answer is missed, you get zero marks.

61. Which of the following is / are the unit / s of magnetic field ?

(a) tesla (b) newton / ampere-meter (c) weber / meter^2 (d) volt-second / meter^2

62. The inductance of a solenoid varies

(a) directly as the area of cross section.
(b) directly as the square of the number of turns.
(c) inversely as the length of the solenoid.
(d) directly as the volume enclosed by the solenoid.

63. Which of the following statement/s in case of a thermodynamic process is/are correct? (The symbols carry their usual meaning.)

(a) $\Delta E_{\text{int}} = W$ indicates an adiabatic process.
(b) $\Delta E_{\text{int}} = Q$ suggests an isochoric process.
(c) $\Delta E_{\text{int}} = 0$ is true for a cyclic process.
(d) $\Delta E_{\text{int}} = -W$ indicates an adiabatic process.

64. With a rise of temperature

(a) surface tension of water decreases. (b) viscosity of water decreases.
(c) viscosity of air decreases. (d) viscosity of air increases.

65. Which of the following statement/s is/are correct in case of a source of emf (such as a primary cell)?

(a) Inside the cell there always exist an electrostatic field and a non-electrostatic field of equal magnitude directed opposite to it.
(b) Potential difference is the work of an electrostatic field whereas electromotive force is the work of a non-electrostatic field.
(c) Under certain condition current can flow from positive terminal to negative terminal within the cell.
(d) When an external resistance is connected to the cell, the electrostatic field inside the cell decreases in magnitude compared to the non-electrostatic field.

66. Which of the following statement/s is/are correct in case of a resistance in a resistance box used in a laboratory?

(a) The resistance is prepared using tungsten or nichrome wire.
(b) The resistance is prepared using manganin wire.
(c) Half of the length of the resistance wire is wound clockwise and the remaining half anticlockwise just to accommodate the whole length in a small space.
(d) Half of the length of the resistance wire is wound clockwise and the remaining half anticlockwise to make the inductive effect zero.

67. In a certain experiment density of the material of a small metallic cylindrical tube of a given mass is to be determined. Its length is about 3 cm, outer diameter more than about 1 cm and wall thickness about 2mm; the flat base being a little thicker than 2mm. Which of the following set/s of apparatus can be used to determine the volume of the tube accurately?

(a) Water and a measuring cylinder.
(b) Water, a measuring cylinder and a micrometer screw gauge.
(c) An overflow vessel, a measuring cylinder and water.
(d) Only verniercallipers.

68. An object and a screen are separated by a distance D. A convex lens of focal length f such that $4f<D$, is moved between the object and the screen to get two sharp images. If the two positions of the lens are separated by a distance L, then

(a) L is equal to $\sqrt{D(D-4f)}$.
(b) object distance in one position is numerically equal to image distance in the other position.
(c) the ratio of sizes of the two images is $\frac{(D-L)}{(D+L)}$.
(d) the ratio of sizes of the two images is $\frac{(D-L)^2}{(D+L)^2}$.

69. A transistor (*pnp* or *npn*) can be used as

(a) an amplifier.
(b) an oscillator.
(c) a switch.
(d) a current source.

70. When photons each with energy 4.25 eV strike the surface of a metal A, the photoelectrons given out have maximum kinetic energy T_A and the corresponding de Broglie wave length isλ_A. When another metal surface B is irradiated with photons each with energy 4.70 eV, the corresponding maximum kinetic energy $T_B$is 1.50eV less thanT_A. If the de Broglie wave length λ_B of these photoelectrons is twice that of λ_A, then

(a) work function of metal A is 2.25 eV.
(b) work function of metal A is 4.20 eV.
(c) $T_A = 2.0$ eV.
(d) the radiation incident on metal A has a wavelength 292 nm.

-x-x-x-x-x-x-x-x-x-

Physical constants you may need…

Magnitude of charge on electron $e = 1.60 \times 10^{-19}$ C
Mass of electron $m_e = 9.10 \times 10^{-31}$ kg
Universal gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/ kg^2
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2
Universal gas constant $R = 8.31$ J/mol K
Planck constant $h = 6.62 \times 10^{-34}$Js
Stefan constant $\sigma = 5.67 \times 10^{-8}$ W/m^2K^4
Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg
Faraday constant = 96,500 C/mol
Boiling point of nitrogen = 77.4 K
Boiling point of oxygen = 90.19 K
Boiling point of hydrogen =20.3 K
Boiling point of helium = 4.20 K

Rough Page

NSEP - 2015										
P105			P136			P177			P198	
Q.No.	Answer key		Q.No	Answer key		Q.No	Answer key		Q.No	Answer key
1	B		1	B		1	B		1	B
2	D		2	D		2	D		2	D
3	B		3	B		3	B		3	B
4	D		4	D		4	D		4	D
5	B		5	B		5	B		5	B
6	D		6	D		6	D		6	D
7	B		7	B		7	B		7	B
8	C		8	C		8	C		8	C
9	B		9	B		9	B		9	B
10	D		10	D		10	D		10	D
11	C		11	D		11	B		11	D
12	C		12	B		12	D		12	D
13	D		13	D		13	B		13	C
14	C		14	D		14	C		14	B
15	B		15	A		15	A		15	D
16	B		16	C		16	C		16	B
17	B		17	B		17	A		17	D
18	D		18	deleted		18	D		18	C
19	B		19	B		19	C		19	B
20	D		20	A		20	A		20	A
21	D		21	C		21	D		21	C

NSEP - 2015							
P105		**P136**		**P177**		**P198**	
Q.No.	**Answer key**	**Q.No**	**Answer key**	**Q.No**	**Answer key**	**Q.No**	**Answer key**
22	D	22	D	22	B	22	C
23	C	23	B	23	D	23	D
24	B	24	D	24	D	24	C
25	D	25	D	25	A	25	B
26	B	26	B	26	C	26	B
27	D	27	D	27	B	27	B
28	C	28	B	28	deleted	28	D
29	B	29	D	29	B	29	B
30	A	30	D	30	A	30	D
31	B	31	C	31	C	31	D
32	D	32	C	32	D	32	B
33	B	33	D	33	B	33	D
34	C	34	C	34	D	34	D
35	A	35	B	35	D	35	A
36	C	36	B	36	B	36	C
37	A	37	B	37	D	37	B
38	D	38	D	38	B	38	deleted
39	C	39	B	39	D	39	B
40	A	40	D	40	D	40	A
41	D	41	B	41	C	41	C
42	B	42	D	42	C	42	D

NSEP - 2015										
P105			P136			P177			P198	
Q.No.	Answer key		Q.No	Answer key		Q.No	Answer key		Q.No	Answer key
43	D		43	B		43	D		43	B
44	D		44	C		44	C		44	D
45	A		45	A		45	B		45	D
46	C		46	C		46	B		46	B
47	B		47	A		47	B		47	D
48	deleted		48	D		48	D		48	B
49	B		49	C		49	B		49	D
50	A		50	A		50	D		50	D
51	C		51	D		51	D		51	B
52	D		52	D		52	D		52	D
53	B		53	C		53	C		53	B
54	D		54	B		54	B		54	C
55	D		55	D		55	D		55	A
56	B		56	B		56	B		56	C
57	D		57	D		57	D		57	A
58	B		58	C		58	C		58	D
59	D		59	B		59	B		59	C
60	D		60	A		60	A		60	A
61	ABCD		61	BD		61	ABCD		61	BD
62	ABC		62	BCD		62	ABC		62	BCD
63	BCD		63	ABD		63	BCD		63	ABD

NSEP - 2015										
P105			**P136**			**P177**			**P198**	
Q.No.	**Answer key**		**Q.No**	**Answer key**		**Q.No**	**Answer key**		**Q.No**	**Answer key**
64	ABD		64	ABCD		64	ABD		64	ABCD
65	BCD		65	ABCD		65	BCD		65	ABCD
66	BD		66	ABC		66	BD		66	ABC
67	BCD		67	BCD		67	BCD		67	BCD
68	ABD		68	ABD		68	ABD		68	ABD
69	ABCD		69	BCD		69	ABCD		69	BCD
70	ABCD		70	ABCD		70	ABCD		70	ABCD

All quires regarding the answer keys should be sent only to iaptpune@gmail.com with in December 2nd 2015

INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS 2018 -19

Date of Examination: 25TH November, 2018

Time: 0830 to 1030 Hrs

Q. Paper Code: P160

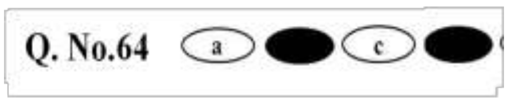
Write the question paper code mentioned above on YOUR answer sheet (in the space provided), otherwise your answer sheet will NOT be assessed. Note that the same Q. P. Code appears on each page of the question paper.

Instructions to Candidates –

1. Use of mobile phones, smartphones, ipads during examination is **STRICTLY PROHIBITED**.
2. In addition to this question paper, you are given answer sheet along with Candidate's copy.
3. On the answer sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/carelessly filled information may disqualify your candidature.
4. On the answer sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. The email ID and date birth entered in the answer sheet will be your login credentials for accessing performance report. Please take care while entering.
6. Question paper has two parts. In part A1 (Q. No. 1 to 60) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   In part A2 (Q. No. 61 to 70) each question has four alternatives out of which **any number of alternative (**1, 2, 3 or 4**) may be correct.** You have to choose ALL correct alternatives and fill the appropriate bubbles, as shown

7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Any rough work should be done only in the space provided.
9. Use of **non-programmable** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting your answer paper, take away the Candidate's copy for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the answer sheet.

Answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED.

Scratching or overwriting may result in a wrong score.

P160

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (continued) –

Read the following instructions after submitting the answer sheet.

12. **Comments regarding this question paper, if any, may be filled in Google forms only at https://goo.gl/forms/9GP03NRgUVuhWJn52 till 28th November, 2017.**
13. **The answers/solutions to this question paper will be available on our website – www.iapt.org.in by 2nd December, 2017.**
14. **CERTIFICATES and AWARDS –**
    Following certificates are awarded by the IAPT to students successful in NSEs

    (i) "Centre Top 10%" that will be sent to NSE centre by post.

    (ii) "Statewise Top 1%" that can be downloaded after Feb -15th, 2019 from iapt.org.in

    (iii) "National Top 1%". Certificates can be downloaded after Feb -15th, 2019 iapt.org.in

15. Result sheets can be downloaded from our website in the month of February. The "Centre Top 10%" certificates will be dispatched to the Prof-in-charge of the centre by February, 2018.
16. List of students (with centre number and roll number only) having score above MAS will be displayed on our website (www.iapt.org.in) by **22nd December, 2017.** See the **Eligibility Clause** in the Student's brochure on our website.
17. Students eligible for the INO Examination on the basis of selection criteria mentioned in Student's brochure will be informed accordingly.

Physical constants you may need…

Magnitude of charge on electron $e = 1.60 \times 10^{-19}$ C	Mass of electron $m_e = 9.10 \times 10^{-31}$ kg
Universal gas constant $R = 8.31$ J/mol K	Planck constant $h = 6.62 \times 10^{-34}$ Js
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Boiling point of nitrogen = 77.4 K	Boiling point of oxygen = 90.19 K
Boiling point of hydrogen = 20.3 K	Boiling point of helium = 4.2 K
Universal gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/ Kg^2	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2

P160

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS 2018-19
Total Time : 120 minutes (A-1 and A-2)

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT.

1) The SI unit of permeability of free space is

(a) $\frac{\text{weber}}{\text{ampere}}$ (b) $\frac{\text{henry}}{\text{ampere}}$ (c) $\frac{\text{tesla}}{\text{ampere–meter}}$ (d) $\frac{\text{weber}}{\text{ampere–meter}}$

2) A uniform solid drum of radius R and mass M rolls without slipping down a plane inclined at an angle θ. Its acceleration along the plane is

(a) $\frac{1}{3} g \sin\theta$ (b) $\frac{1}{2} g \sin\theta$ (c) $\frac{2}{3} g \sin\theta$ (d) $\frac{5}{7} g \sin\theta$

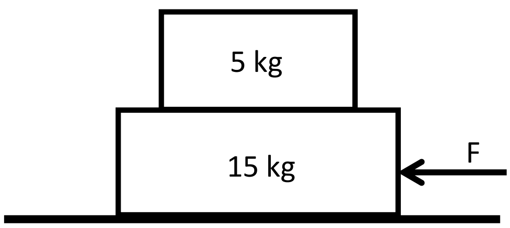
3) A particle moves according to the law $x = at$, $y = at\,(1-\alpha t)$ where a and α are positive constants and t is time. The time instant at which velocity makes an angle $\frac{\pi}{4}$ with acceleration is

(a) $\frac{4}{\alpha}$ (b) $\frac{3}{\alpha}$ (c) $\frac{2}{\alpha}$ (d) $\frac{1}{\alpha}$

4) The potential energy of a particle of mass m in a conservative force field can be expressed as $U = \alpha x - \beta y$ where (x, y) denote the position coordinates of the body. The acceleration of the body is

(a) $\frac{\alpha-\beta}{m}$ (b) $\frac{\alpha+\beta}{m}$ (c) $\frac{\sqrt{\alpha^2-\beta^2}}{m}$ (d) $\frac{\sqrt{\alpha^2+\beta^2}}{m}$

5) A constant force F applied to the lower block of mass 15 kg makes it slide between the upper block of mass 5 kg and the table below, as shown. The coefficients of static (μ_s) and kinetic (μ_k) friction between the lower block and the table are 0.5 and 0.4 respectively and those between the two blocks are 0.3 and 0.1. The accelerations of the upper and the lower blocks are respectively



(a) 1.96 m/s^2 and 1.96 m/s^2 b) 1.96 m/s^2 and 3.92 m/s^2
(c) 0.98 m/s^2 and 0.49 m/s^2 d) 0.98 m/s^2 and 1.96 m/s^2

6) Two bodies of equal masses moving with equal speeds make a perfectly inelastic collision. If the speed after the collision is reduced to half, the angle between their velocities of approach is

(a) 30° (b) 60° (c) 90° (d) 120°

7) A student performs an experiment with a simple pendulum and records the time for 20 oscillations. If he would have recorded time for 100 oscillations, the error in the measurement of time period would have reduced by a factor of

(a) 80 (b) 20 (c) 10 (d) 5

8) A satellite is launched from a point close to the surface of the earth (radius R) with a velocity $v = v_0\sqrt{1.5}$, where v_0 is the velocity in a circular orbit. If the initial velocity imparted to the satellite is horizontal, the maximum distance from the surface of the earth during its revolution is

(a) R (b) $2R$ (c) $3R$ (d) $4R$

9) The aperture diameter of a plano-convex lens is 6 cm and its thickness is 3 mm. If the speed of light through its material is $v = 2\times10^{8}$ m/s, the focal length of the lens is

(a) 40 cm. (b) 35 cm. (c) 30 cm. (d) 20 cm.

10) Under standard conditions of temperature and pressure a piece of ice melts completely on heating it. Obviously the increase in internal energy of the system (ice and water) is

(a) equal to the heat given.
(b) more than the heat given.
(c) less than the heat given.
(d) zero.

11) Rocket fuel is capable of giving an exhaust velocity of v_{rel} = 2.4 km/s in the absence of any external forces. The fuel required per kg of the payload to provide an exhaust velocity of 12 km/s to the rocket is

(a) 3670 kg (b) 8000 kg (c) 147.4 kg (d) 478.4 kg

12) A vertical spring of length l_0 and force constant K is stretched by l when a mass m is suspended from its lower end. By pulling the mass down a little the system is left off to oscillate. The time period of oscillation is

(a) $2\pi\sqrt{\frac{l}{g}}$ (b) $2\pi\sqrt{\frac{l_0}{g}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{m}{K}}$ (d) $2\pi\sqrt{\frac{l+l_0}{g}}$

13) Let R be the radius of the earth. In general, the loss of gravitational potential energy of a body of mass m falling from a height h to the earth surface is

(a) mgh (b) $mgh\frac{R}{R+h}$ (c) $mgh\sqrt{\frac{R+h}{R}}$ (d) $mgh\sqrt{\frac{R}{R+h}}$

14) The velocity of a projectile at the highest point of its trajectory is $\sqrt{0.4}$ of its velocity at a point at half its maximum height. The angle of projection is

(a) 30^{o} (b) 45^{o} (c) 60^{o} (d) $\tan^{-1}(\sqrt{0.4})$

15) The combination of a steel wire (length 80 cm, area of cross section 1 mm^2) and an aluminium wire (length 60 cm, area of cross section 3 mm^2) joined end to end is stretched by a tension of 160 N. If the densities of steel and aluminium are 7.8 g/cc and 2.6 g/cc respectively then, the minimum frequency of a tuning fork which can produce standing waves in the composite wire, with the joint as a node, is

(a) 179 Hz. (b) 358 Hz. (c) 88 Hz. (d) 118 Hz.

16) In a stationary wave

(a) all the medium particles vibrate in the same phase.
(b) all the particles between two consecutive nodes vibrate in the same phase.
(c) any two consecutive nodes vibrate in the same phase.
(d) all the particles between two consecutive antinodes vibrate in the same phase.

17) An empty earthen pitcher is kept under a water tap and starts filling with water as the tap is opened. The pitch of the sound produced

(a) goes on decreasing.
(b) goes on increasing.
(c) first increases and then decreases after the pitcher is half filled.
(d) does not change.

18) The molar specific heat of an ideal gas in a certain thermodynamic process is $\frac{\alpha}{T}$ where α is a constant. If the adiabatic exponent is $\gamma = \frac{C_P}{C_V}$, the work done in heating the gas from T_0 to nT_0 is

(a) $\frac{1}{\alpha}\ln n$ (b) $\alpha\ln n - \frac{(n-1)}{(\gamma-1)}RT_0$ (c) $\alpha\ln n - (\gamma-1)RT_0$ (d) $\frac{(n-1)}{(\gamma-1)}RT_0$

19) An aircraft flies at a speed v from city A to city B and back in time t_0. City B is to the east of city A at a distance d. The aircraft takes time t_1 for the round trip if wind blows with speed w along AB and time t_2 if the wind blows with the same speed perpendicular to AB. Then,

(a) $t_1 = t_2 = t_0$ (b) $t_1 > t_2 > t_0$ (c) $t_1 < t_2 < t_0$ (d) $t_1 > t_0 > t_2$

20) The Hubble telescope in orbit above the earth has a 2.4 m circular aperture. The telescope has equipment for detecting ultraviolet light. The minimum angular separation between two objects that the telescope can resolve in ultraviolet light of wavelength 95 nm is
(a) 4.83×10^{-8} rad (b) 4.03×10^{-8} rad (c) 2.41×10^{-8} rad (d) 2.00×10^{-8} rad

21) A projectile is fired from ground with velocity u at an angle θ with the horizontal. It would be moving perpendicular to its initial direction of projection after a time t equal to

(a) $\dfrac{u\sin\theta}{g}$ (b) $\dfrac{2u\sin\theta}{g}$ (c) $\dfrac{u}{g\sin\theta}$ (d) $\dfrac{u}{2g\sin\theta}$

22) The critical angle for light passing from glass to air is minimum for the light of wavelength

(a) 0.7 μ m (b) 0.6 μ m (c) 0.5 μ m (d) 0.4 μ m

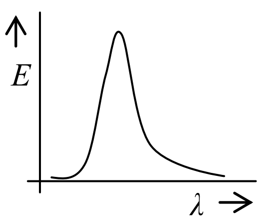
23) A thin hollow equiconvex lens, silvered at the back, converges a beam of light parallel to the principal axis at a distance 0.2 m. When filled with water ($\mu = \frac{4}{3}$), the same beam will be converged at a distance of
(a) 0.40 m. (b) 0.20 m. (c) 0.12 m. (d) none of the above

24) An air bubble is situated at a distance 2.0 cm from the centre of a spherical glass paper-weight of radius 5.0 cm and refractive index 1.5. The bubble is seen through the nearest surface. It appears at a distance v from the centre. Therefore, v is

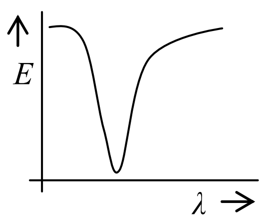
(a) 3.75 cm. (b) 3.25 cm. (c) 2.50 cm. (d) 3.80 cm.

25) A student while performing experiment with a sonometer with bridges separated by a distance of 80 cm, missed out some of the observations. However, he claimed that the three resonant frequencies for a given tuning fork were 84, 140 and 224 Hz. The speed of transverse waves on the wire is
(a) 33.30 m/s. (b) 330.0 m/s. (c) 44.80 m/s. (d) 448.0 m/s.

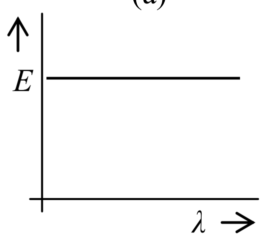
26) Which of the following curves represents spectral distribution of energy of black body radiation?



(a)



(b)



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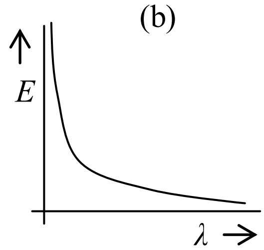


(d)

27) A sphere and a cube having equal surface area are made of the same material. The two are heated to the same temperature and kept in identical surrounding. The ratio of their initial rates of cooling is

(a) 1 : 1 (b) $\sqrt{\frac{\pi}{2}}$: 1 (c) $\sqrt{\frac{\pi}{3}}$: 1 (d) $\sqrt{\frac{\pi}{6}}$: 1

28) Consider the diffraction pattern due to a single slit. The first maximum for a certain monochromatic light coincides with the first minimum for red light of wavelength 660 nm. The wavelength of the monochromatic light is

(a) 660 nm. (b) 550 nm. (c) 440 nm. (d) 330 nm.

29) A concave lens of focal length f produces an image $(1/n)$ times the size of the object. The distance of the object from the lens is

(a) $(n + 1)f$ (b) $\frac{(n-1)}{n}f$ (c) $\frac{(n+1)}{n}f$ (d) $(n - 1)f$

30) The Sun having radius R and surface temperature T, emits radiation as a perfect emitter. The distance of the earth from the sun is r and the radius of the earth is R_e. The total radiant power incident on the earth is

(a) $\frac{R_e^2 R^2 \sigma T^4}{4\pi r^2}$ (b) $\frac{R_e^2 R^2 \sigma T^4}{r^2}$ (c) $\frac{4\pi R_e^2 R^2 \sigma T^4}{r^2}$ (d) $\frac{\pi R_e^2 R^2 \sigma T^4}{r^2}$

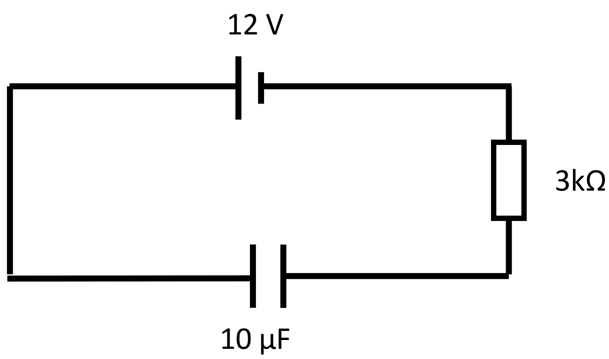
31) A cylinder containing water (refractive index 4/3) is covered by an equiconvex glass (refractive index 3/2) lens of focal length 25 cm. At the mid-day when the sun is just overhead, the image of the sun will be seen at a distance of

(a) 100 cm. (b) 50 cm. (c) 37.5 cm. (d) 25 cm.

32) A rectangular loop carrying a current is placed in a uniform magnetic field. The net force acting on the loop

(a) depends on the direction and magnitude of the current.
(b) depends on the direction and magnitude of the magnetic field.
(c) depends on the area of the loop.
(d) is zero.

33) The capacitor in the circuit shown below carries a charge of 30 μC at a certain time instant. The rate at which energy is being dissipated in the 3kΩ resistor at that instant is

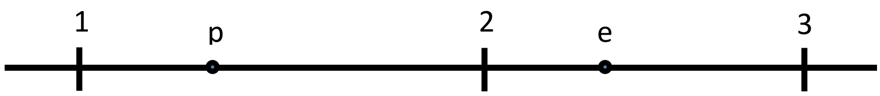


(a) 4 mW (b) 9 mW
(c) 27 mW (d) 48 mW

34) A hollow conducting sphere of radius 15 cm has a uniform surface charge density $+3.2\ \mu\text{C/m}^2$. When a point charge q is placed at the centre of the sphere, the electric field at 25 cm from the centre just reverses its direction keeping the magnitude the same. Therefore, q is

(a) $+\ 0.91\ \mu$C (b) $-0.91\ \mu$C (c) $+\ 1.81\ \mu$C (d) $-1.81\ \mu$C

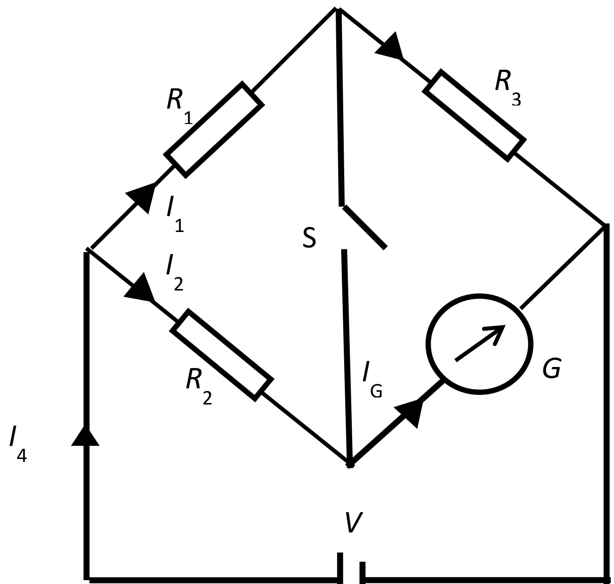
35) An electron (e) and a proton (p) are situated on the straight line as shown below. The directions of the electric field at the points 1, 2 and 3 respectively, are shown as



(a) $\longrightarrow \quad \longleftarrow \quad \longrightarrow$
(b) $\longleftarrow \quad \longrightarrow \quad \longleftarrow$
(c) $\longleftarrow \quad \longrightarrow \quad \longrightarrow$
(d) $\longrightarrow \quad \longleftarrow \quad \longleftarrow$

36) In the circuit shown $R_1 \neq R_2$. The reading in the galvanometer is the same with switch S open or closed. Then,

(a) $I_1 = I_G$ (b) $I_2 = I_G$
(c) $I_3 = I_G$ (d) $I_4 = I_G$



37) A thin wire of length 1 m is placed perpendicular to the XY plane. If it is moved with velocity $\vec{v} = 4\hat{\imath} - \hat{\jmath}$ m/s in the region of magnetic induction $\vec{B} = \hat{\imath} + 4\hat{\jmath}$ Wb/m^2. The potential difference developed between the ends of the wire is

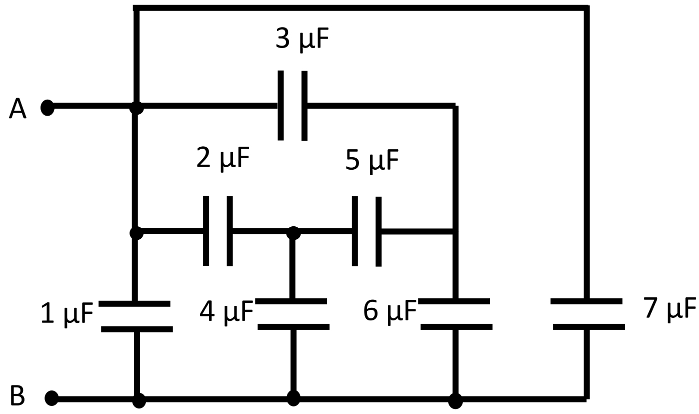
(a) zero. (b) 3 V. (c) 15 V. (d) 17 V.

38) A steel cooking pan has copper coating at its bottom. The thickness of copper coating is half the thickness of steel bottom. The conductivity of copper is three times that of steel. If the temperature of blue flame is 119°C and that of the interior of the cooking pan is 91°C, then the temperature at the interface between the steel bottom and the copper coating in the steady state is

(a) 98°C (b) 103°C (c) 115°c (d) 108°C

39) The total capacitance between points A and B in the arrangement shown below is

(a) 28 μF
(b) $\frac{34}{7}$ μF
(c) 23 μF
(d) $\frac{34}{3}$ μF



40) A fiber sheet of thickness 1 mm and a mica sheet of thickness 2 mm are introduced between two metallic parallel plates to form a capacitor. Given that the dielectric strength of fiber is 6400 kV/m and the dielectric constants of fiber and mica are 2.5 and 8 respectively, the electric field inside the mica sheet just at the breakdown of fiber will be

(a) 2000 kV/m (b) 2048 kV/m (c) 3200 kV/m (d) 6400 kV/m

41) The position vector of a point mass is expressed as $\vec{r} = at\hat{\imath} + bt^2\hat{\jmath}$. The trajectory of the particle is

(a) a straight line. (b) a parabola. (c) a hyperbola. (d) none of the above.

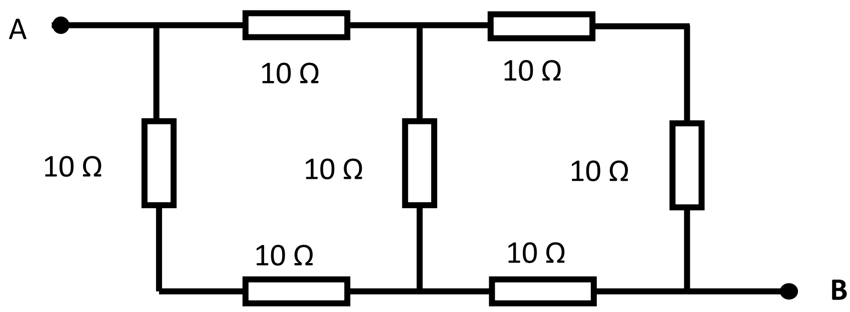
42) In a series LCR circuit fed with an alternating emf $E = E_0 \sin \omega t$,

(a) the voltage across L is in phase with the applied emf E.
(b) the voltage across C is in phase with the applied emf E.
(c) the voltage across R is in phase with the applied emf E.
(d) the voltages across L, C and R are all in phase with the applied emf E.

43) A conducting wire is bent in the form of a n sided regular polygon enclosed by a circle of radius R. The magnetic field produced at its centre by a current i flowing through the wire is

(a) $\frac{\mu_0 i}{2R} \frac{\sin\frac{\pi}{n}}{\frac{\pi}{n}}$ (b) $\frac{\mu_0 i}{2R} \frac{\cos\frac{\pi}{n}}{\frac{\pi}{n}}$ (c) $\frac{\mu_0 i}{2R} \frac{\tan\frac{\pi}{n}}{\frac{\pi}{n}}$ (d) $\frac{\mu_0 i}{2R} \frac{\cot\frac{\pi}{n}}{\frac{\pi}{n}}$

44) The effective resistance between points A and B in the circuit arrangement shown below is



(a) 14 Ω.
(b) 15 Ω.
(c) 30 Ω.
(d) none of the above.

45) The magnetic dipole moment of an electron in the S state of hydrogen atom revolving in a circular orbit of radius 0.0527 nm with a speed 2.2×10^{6} m/s is

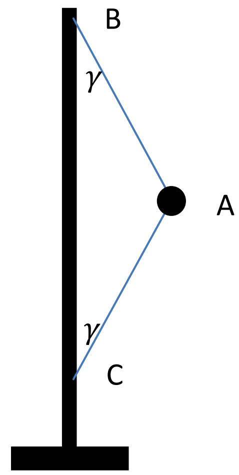
(a) 4.64×10^{-24} Am^2 (b) 9.28×10^{-24} Am^2 (c) 18.56×10^{-24} Am^2 (d) 2.32×10^{-24} Am^2

46) A steel cable hanging vertically can support a maximum load W. The cable is cut to exactly half of its original length, the maximum load that it can support now is

(a) W. (b) $\frac{W}{2}$. (c) $2W$. (d) more than $\frac{W}{2}$ but less than W.

47) The strings AB and AC each of length 40 cm, connect a ball of mass 200 g to a vertical shaft as shown. When the shaft rotates at a constant angular speed ω, the ball travels in a horizontal circle with the strings inclined at $\gamma = 30^{\circ}$ to the shaft. If the tension in the string AC is 4 N, that in the string AB and the angular speed ω respectively, are

(a) 6.26 N and 11.32 rad/s
(b) 7.92 N and 14.32 rad/s
(c) 7.92 N and 11.32 rad/s
(d) 6.26 N and 14.32 rad/s



48) A tightly wound long solenoid carries a current 5 A. An electron shot perpendicular to the solenoid axis inside it revolves at a frequency 10^{8} rev/s. The number of turns per meter length of the solenoid is

(a) 57 (b) 176 (c) 569 (d) 352

49) The same alternating voltage $v = V_0 \sin(\omega t)$ is applied in both the LCR circuits shown below. The current through the resistance R at resonance is

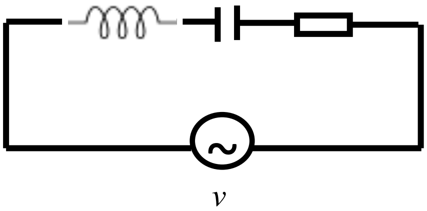


Fig 1

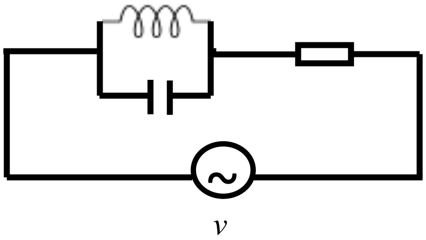
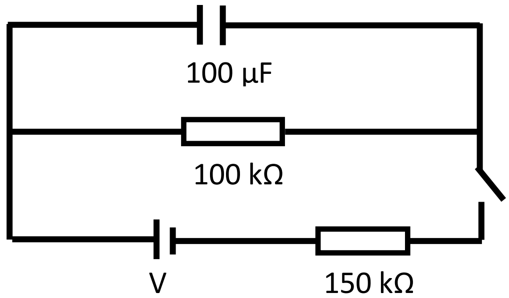


Fig 2

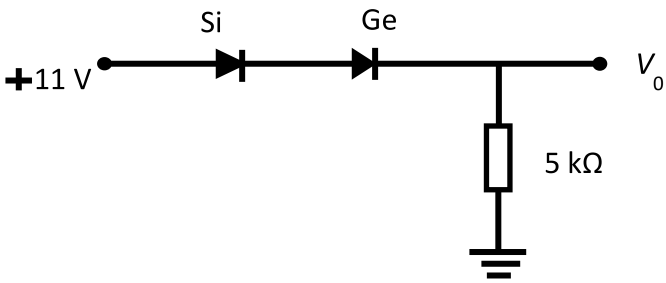
(a) maximum in Fig. (1) and maximum in Fig. (2).
(b) minimum in Fig. (1) and maximum in Fig. (2).
(c) maximum in Fig. (1) and minimum in Fig. (2).
(d) minimum in Fig. (1) and minimum in Fig. (2).

50) The switch S in the circuit shown is closed for a long time and then opened at time $t = 0$. The current in the 100 kΩ resistance at $t = 3$s is



(a) zero.
(b) 48 μA.
(c) 35.5 μA.
(d) 16 μA.

51) In the network shown below the voltage V_0 is nearly



(a) 10 volt.
(b) 11 volt.
(c) 12 volt.
(d) zero volt.

52) The energy of the characteristic X-ray photon in a Coolidge tube comes from

(a) the kinetic energy of striking electron.
(b) the kinetic energy of the free electrons of the target.
(c) the kinetic energy of the ions of the target.
(d) the electronic transition of the target atom.

53) The maximum wavelength that can ionize a hydrogen atom initially in the ground state is

(a) 660.0 nm. (b) 364.5 nm. (c) 121.9 nm. (d) 91.4 nm.

54) The wavelength of the waves associated with a proton and a photon are the same. Therefore, the two have equal

(a) mass. (b) velocity. (c) momentum. (d) kinetic energy.

55) Which of the following sources emits light having highest degree of coherence?

(a) Light Emitting Diode.
(b) LASER diode.
(c) Neon lamp.
(d) Incandescent lamp.

56) An alpha particle with kinetic energy K approaches a stationary nucleus having atomic number Z. The distance of closest approach is b. Therefore the distance of closest approach for a nucleus of atomic number $2Z$ is

(a) $b/2$. (b) $\sqrt{2}\,b$. (c) $2\,b$. (d) $4\,b$.

57) In a photodiode the reverse current increases when exposed to light of wavelength 620 nm or less. The band gap of the semiconductor used is

(a) 0.67 eV. (b) 1.12 eV. (c) 2.00 eV. (d) 2.42 eV.

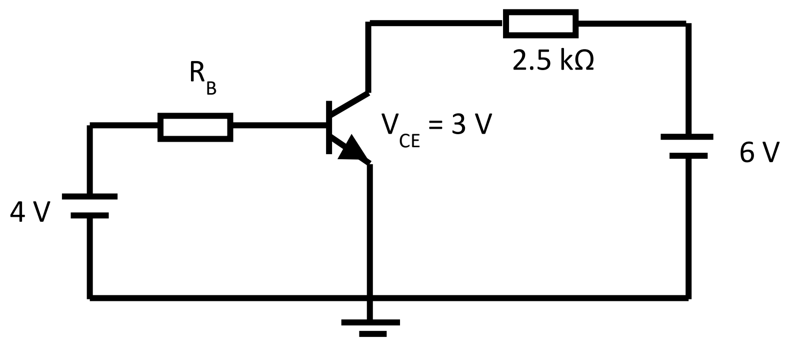
58) An electron in hydrogen atom jumps from a level $n = 4$ to $n = 1$. The momentum of the recoiled atom is

(a) 6.8×10^{-27} kg-m/s (b) 12.75×10^{-19} kg-m/s (c) 13.6×10^{-19} kg-m/s (d) zero.

59) For the Boolean equation $Y = AB + A(B + C) + B(B + C) + \bar{B}$, which of the following statements is correct?

(a) Y does not depend on A but depends on B.
(b) Y does not depend on B but depends on A.
(c) Y does not depend on B.
(d) Y depends only on C.

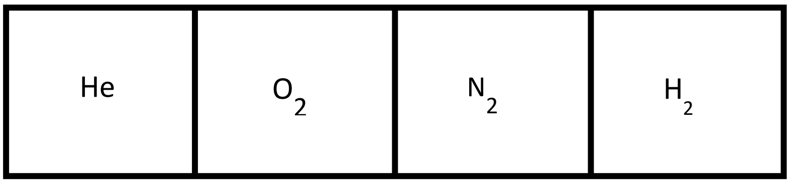
60) Refer to the common emitter amplifier circuit shown below, using a transistor with $\beta = 80$ and $V_{BE} = 0.7$ volt. The value of resistance R_B is



(a) 330 Ω. (b) 330 kΩ. (c) 220 Ω. (d) 220 kΩ.

A 2

61) A horizontal insulated cylinder of volume V is divided into four identical compartments by stationary semi-permeable thin partitions as shown. The four compartments from left are initially filled with 28 g helium, 160 g oxygen, 28 g nitrogen and 20 g hydrogen respectively. The left partition lets through hydrogen, nitrogen and helium while the right partition lets through hydrogen only.The middle partition lets through hydrogen and nitrogen both. The temperature T inside the entire cylinder is maintained constant. After the system is set in equilibrium,



(a) pressure of helium is $\frac{14\,RT}{V}$.

(b) pressure of oxygen is $\frac{20\,RT}{V}$.

(c) pressure of nitrogen is $\frac{4\,RT}{3V}$.

(d) pressure of hydrogen is $\frac{10\,RT}{V}$.

62) After charging a capacitor C to a potential V, it is connected across an ideal inductor L. The capacitor starts discharging simple harmonically at time t = 0. The charge on the capacitor at a later time instant is q and the periodic time of simple harmonic oscillations is T. Therefore,

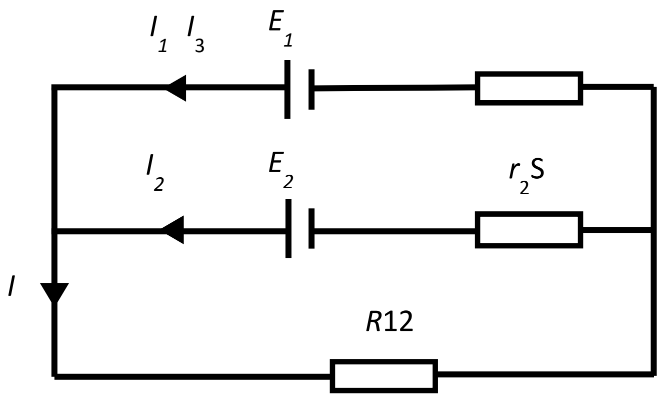
(a) $q = CV \sin(\omega t)$

(b) $q = CV \cos(\omega t)$

(c) $T = 2\pi \sqrt{\frac{1}{LC}}$

(d) $T = 2\pi \sqrt{LC}$

63) In the circuit arrangement shown two cells supply a current I to a load resistance R = 9 Ω. One cell has an emf E_1 = 9 V and internal resistance r_1 = 1 Ω and the other cell has an emf E_2 = 6 V and internal resistance r_2 = 3 Ω. The currents are as shown. Then,



(a) I_1 = 0.9 A and I_2 = 0.5 A.

(b) $I \cong 0.85$ A.

(c) if the cell of emf E_1 is removed, current I will be smaller.

(d) if the cell of emf E_2 is removed, current I will be smaller.

64) A transparent cylindrical rod of length l = 50 cm, radius R = 10 cm and refractive index $\mu = \sqrt{3}$ lies onto a horizontal plane surface. A ray of light moving perpendicular to its length is incident on the rod horizontally at a height h above the plane surface such that this ray emerges out of the rod at a height 10 cm above the plane surface. Therefore, h is

(a) 1.34 cm. (b) 1.73 cm. (c) 10.0 cm (d) 18.66 cm.

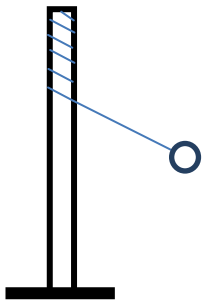
65) Two point charges +1 μC and -1 μC are placed at points (0, -0.1 m) and (0, +0.1 m) respectively in XY plane. Then, choose the correct statement/s from the following.

(a) The electric field at all points on the Y axis has the same direction.
(b) The dipole moment is 0.2 μC-m along + X axis direction.
(c) No work has to be done in bringing a test charge from infinity to the origin.
(d) Electric field at all points on the X axis is along + Y axis.

66) An inductance L, a resistance R and a battery B are connected in series with a switch S. The voltages across L and R are V_L and V_R respectively. Just after closing the switch S,

(a) V_L will be greater than V_R.
(b) V_L will be less than V_R.
(c) V_L will be the same as V_R.
(d) V_L will decrease while V_R will increase as time progresses.

67) A string of length l, tied to the top of a pole, carries a ball at its other end as shown. On giving the ball a single hand blow perpendicular to the string, it acquires an initial velocity v_0 in the horizontal plane and moves in a spiral of decreasing radius by curling itself around the pole. Therefore,



(a) the instantaneous centre of revolution of the ball is the point of contact of the string with the pole at that instant.
(b) the instantaneous centre of revolution of the ball will be fixed at the point where the string was initially fixed.
(c) the angular momentum of the system will not be conserved.
(d) the angular momentum of the system will be conserved.

68) A circular loop of conducting wire of radius 1 cm is cut at a point A on its circumference. It is then folded along a diameter through A such that the two semicircular loops lie in two mutuially perpendicular planes. In this region a uniform magnetic field $\vec{B}$ of magnitude 100 mT is directed perpendicular to the diameter through A and makes angles of 30° and 60° with the planes of the two semicircles. The magnetic field reduces at a uniform rate from 100 mT to zero in a time interval of 4.28 ms. Therefore,

(a) instantaneous emf in the two loops are in the ratio $\sqrt{2}$: 1.
(b) instantaneous emf in the two loops are in the ratio $\sqrt{3}$: 1.
(c) the total emf between free ends at point A is 5 mV.
(d) the total emf between free ends at point A is 1.4 mV.

69) A converging lens of focal length 40 cm is fixed at 40 cm in front of a screen. An object placed 120 cm from the fixed lens is required to be focused on the screen by introducing another identical lens in between. The second lens should be placed at a distance x from the object where x is

(a) 40 cm. (b) 50 cm. (c) 140 cm. (d) 150 cm.

70) Mysteriously a charged particle moving with velocity $\vec{v} = v_0\hat{\imath}$ entered the tube of Thomson's apparatus where the parallel metallic plates of length 5 cm along X axis are separated by 2 cm. Under the influence of a magnetic field $\vec{B} = (4.57\times10^{-2}\ \hat{k})$ T, the particle is found to deflect by an angle of 5.7°. When a potential of 2000 volt is applied between the two plates, the particle is found to move straight to the screen without any deflection. Then,

(a) the velocity v_0= 2.19 $\times10^{6}$ m/s.
(b) the charge to mass ratio of the particle is 9.58×10^{7} C/kg.
(c) radius of the circular path in the magnetic field is 50 cm. .
(d) the particle is identified as a proton.

-x-x-x-x-x-x-

ROUGH SHEET