DAY THIRTY EIGHT

Mock Test 1

Instruction

- This question paper contains of 50 Multiple Choice Questions of Physics, divided into two Sections; section A and section B.
- Section A contains 35 questions and all questions are compulsory.
- Section B contains 15 questions out of which only 10 questions are to be attempted.
- Each question carries 4 marks.

Section-A

1 The method of dimensional analysis can be used to derive, which of the following relations?

(a) $N = N_0 e^{-\lambda t}$ (b) $y = A \sin(\omega t + kx)$

(c) $E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ (d) None of these

2 The angle between $\mathbf{A} = \hat{\mathbf{i}} + \hat{\mathbf{j}}$ and $\mathbf{B} = \hat{\mathbf{i}} - \hat{\mathbf{j}}$ is

(a) 45° (b) 90°
(c) –45° (d) 180°

3 A body starts from rest and moves with constant acceleration. The ratio of distance covered by the body in n th second to that covered in n second, is

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

(c) $\frac{n^2}{2n-1}$ (d) $\frac{2n-1}{2n^2}$

4 A passenger in a train drops a ball from the window of a train running at an acceleration a. A pedestrian on the ground by the side of the rails observes the ball falling along

(a) a vertical path with an acceleration $\sqrt{g^2 + a^2}$

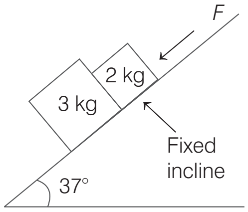
(b) a vertical path with an acceleration $\sqrt{g^2 - a^2}$

(c) a parabola with an acceleration $\sqrt{g^2 + a^2}$

(d) a parabola with an acceleration g

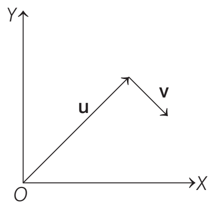
5 Two blocks of masses 3 kg and 2 kg are placed side by side on an incline as shown in the figure. A force $F = 20\,\text{N}$ is acting on 2 kg block along the incline.

The coefficient of friction between the block and the incline in same and equal to 0.1. Find the normal contact force exerted by 2 kg block on 3 kg block.



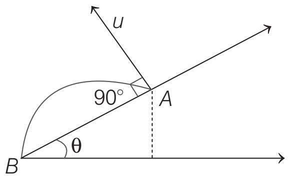
(a) 18 N (b) 30 N
(c) 12 N (d) 27.6 N

6 Figure shows the orientations of two vectors u and v in the XY plane. If $\mathbf{u} = a\,\hat{\mathbf{i}} + b\,\hat{\mathbf{j}}$ and $\mathbf{v} = p\,\hat{\mathbf{i}} + q\,\hat{\mathbf{j}}$
Which of the following is correct?



(a) a and p are positive while b and q are negative
(b) a, p and b are positive while q is negative
(c) a, q and b are positive while p is negative
(d) All a, b, p and q are positive

7 A body is projected from A at an angle of 90° with the plane AB. It again touches the plane at B after time T. Then, what is the length AB?



(a) $Tu \sin\theta$ (b) $Tu \cos\theta$
(c) $Tu \tan\theta$ (d) $Tu \cot\theta$

8 A rigid body rotates about a fixed axis with variable angular velocity equal to $\alpha - \beta t$ at time t, where α and β are constants. Find the angle through which it rotates before it comes to stop.

(a) $\frac{\alpha^2}{2\beta}$ (b) $\frac{\alpha^2 - \beta^2}{2\alpha}$
(c) $\frac{\alpha^2 - \beta^2}{2\beta}$ (d) $\frac{(\alpha - \beta)\alpha}{2}$

9 Satellites orbiting the earth have finite life and sometimes debris of satellites fall to the earth. This is because

(a) the solar cells and batteries in satellites out
(b) the laws of gravitation predict a trajectory spiralling inwards
(c) of various forces causing the speed of satellite and hence height to gradually decrease
(d) of collisions with other satellites

10 A particle performs simple harmonic motion with amplitude A and period T. The mean velocity of the particle over the time interval during which it travels a distance of $\frac{A}{2}$ starting from extreme position is

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

11 The total kinetic energy of all the molecules of helium having a volume V exerting a pressure p is 1500 J. The total KE (in joule) of all the molecules of N_2 having the same volume V and exerting a pressure $2p$, is

(a) 3000 (b) 4000 (c) 5000 (d) 6000

12 500g of water and 100g of ice at 0°C are in a calorimeter whose water equivalent is 40 g. 10g of steam at 100°C is added to it. Then, water in the calorimeter is

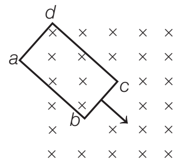
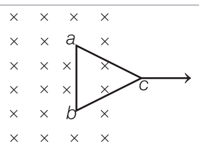
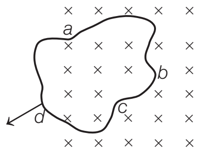
(Latent heat of ice = 80 cal/g, Latent heat of steam = 540 cal/g)

(a) 578 g (b) 590 g
(c) 600 g (d) 610 g

13 A metal ball of surface area 200 cm^2 and at temperature 527°C, is surrounded by a vessel at 27°C. If the emissivity of the metal is 0.4, then the rate of loss of heat from the ball is approximately $\left(\sigma = 5.67 \times 10^{-8} \frac{J}{m^2 s K^4}\right)$

(a) 108 Js^{-1} (b) 168 Js^{-1}
(c) 182 Js^{-1} (d) 192 Js^{-1}

14 Match the Column I (planar loops of different shapes) with Column II (direction of induced current) and select the correct answer from the codes given below.

	Column I		Column II
A.		1.	b a c b
B.		2.	c d a b c
C.		3.	b c d a b

Codes

	A	B	C		A	B	C
(a)	3	1	2	(b)	2	1	3
(c)	1	2	3	(d)	1	3	2

15 A point source emits sound equally in all directions, in a non-absorbing medium. Two points P and Q are at a distance of 9 m and 25 m, respectively from the source. The ratio of the amplitude of the waves at P and Q is

(a) $\frac{3}{5}$ (b) $\frac{5}{3}$ (c) $\frac{9}{25}$ (d) $\frac{25}{9}$

16 If the critical angle for the medium of a prism is C and the angle of prism is A, then there will be no emergent ray, when

(a) $A < 2C$ (b) $A = 2C$ (c) $A > 2C$ (d) $A \geq 2C$

17 Two points separated by a distance of 0.1 mm can just be inspected in a microscope, when a light of wavelength 6000 Å is used. If light of wavelength 4800 Å is used, this limit of resolution will become

(a) 0.8 mm (b) 0.12 mm (c) 0.10 mm (d) 0.08 mm

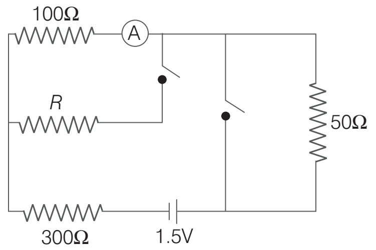
18 A small metallic ball is charged positively and negatively in a sinusoidal manner at a frequency of 10^6 cps. The maximum change on the ball is 10^{-6}C. What is the maximum value of displacement current due to this alternating current?

(a) 6.28 A (b) 3.4 A (c) 3.75×10^{-4} A (d) 12.56 A

19 A capacitor of capacitance $C_1 = 1.0\,\mu F$ withstands a maximum voltage $V_1 = 6.0$ kV while a capacitor of capacitance $C_2 = 2.0\,\mu F$ withstands the maximum voltage $V_2 = 4.0$ kV. What maximum voltage will the system of these capacitors withstand, if they are connected in series?

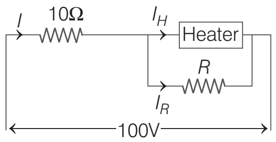
(a) 10 kV (b) 9 kV (c) 12 kV (d) 15 kV

20 In the shown circuit the reading of ammeter is same when both the switches are open, and when both the switches are closed. Assume the ammeter to be ideal, the value of R satisfying above condition is



(a) 100 Ω (b) 400 Ω (c) 600 Ω (d) 440 Ω

21 The power and voltage rating of a heater is 1000 W and 100 V, respectively. What should be the value of R in the given circuit, so that heater operates with power of 62.5 W?



(a) 10 Ω (b) 7.5 Ω (c) 5 Ω (d) 2.5 Ω

22 It takes 16 min to boil some water in an electric kettle. Due to some defect, it becomes necessary to remove 10% turns of the heating coil of the kettle. After repairs, how much time will it take to boil the same mass of water?

(a) 17.7 min (b) 14.4 min
(c) 20.9 min (d) 13.7 min

23 A long wire carries a current of 20 A along the axis of solenoid. The field due to the solenoid is 4 mT. The resultant field at a point 3 mm from the solenoid axis inside solenoid is

(a) 1.33 mT (b) 4.2 mT
(c) 5.33 mT (d) 2.87 mT

24 A mass of 50g of water in a closed vessel, with surroundings at a constant temperature takes 2 min to cool from 30°C to 25°C. A mass of 100g of another liquid in an identical vessel with identical surroundings takes the same time to cool from 30°C to 25°C. The specific heat of the liquid is (The water equivalent of the vessel is 30 g)

(a) 2.0 kcal/kg (b) 4 kcal/kg
(c) 3 kcal/kg (d) 0.5 kcal/kg

25 A 50 Hz, AC current of crest value 2 A flows through the primary of a transformer. If the mutual inductance between the primary and secondary is 0.25 H, the crest voltage induced in the secondary is

(a) 50 V (b) 100 V (c) 200 V (d) 300 V

26 In an L-R circuit, the AC source has voltage 220 V. The potential difference across the inductance is 176 V. The potential difference across the resistance will be

(a) $(220 - 176)$ V
(b) $(220 + 176)$ V
(c) $\sqrt{220 \times 176}$ V
(d) $\sqrt{(220)^2 - (176)^2}$ V

27 A copper wire of length 1.0 m and a steel wire of length 0.5 m having equal cross-sectional areas are joined end to end. The composite wire is stretched by a certain load which stretches the copper wire by 1 mm. If the Young's modulus of copper and steel are respectively $1.0 \times 10^{11} \text{Nm}^{-2}$ and $2.0 \times 10^{11} \text{Nm}^{-2}$, the total extension of the composite wire is

(a) 1.75 mm (b) 2.0 mm
(c) 1.50 mm (d) 1.25 mm

28 The earth's magnetic field lines resemble that of a dipole at the centre of the earth. If the magnetic moment of this dipole is close to 8×10^{22} A-m^2, the value of earth's magnetic field near the equator is close to (radius of the earth $= 6.4 \times 10^6$ m)

(a) 0.6 gauss (b) 1.2 gauss
(c) 1.8 gauss (d) 0.32 gauss

29 The radioactivity of a sample is A_1 at a time t_1 and A_2 at time t_2. If mean life of specimen is T, the number of atoms that have disintegrated in the time interval of $t_2 - t_1$ is

(a) $A_1 - A_2$ (b) $\frac{A_1 - A_2}{T}$
(c) $(A_1 - A_2)T$ (d) $A_1 t_1 - A_2 t_2$

30 The human eye can barely detect a yellow light 6000 Å that delivers 1.7×10^{-18} W to the retina. Nearly, how many photons per second does the retina receive?

(a) 50 (b) 5
(c) 500 (d) More than 5 million

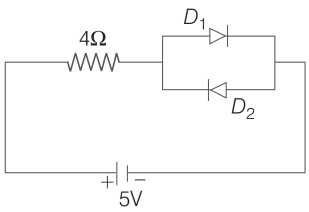
31 According to Bohr's theory (assuming infinite mass of in nucleus), the frequency of the second line of the Balmer series is

(a) 6.16×10^{14} Hz
(b) 6.16×20^{10} Hz
(c) 6.16×10^{13} Hz
(d) 6.16×10^{16} Hz

32 Select the correct statement from the following.

(a) Electromagnetic waves cannot travel in vacuum
(b) Electromagnetic waves are longitudinal waves
(c) Electromagnetic waves are produced by charges moving with uniform velocity
(d) Electromagnetic waves carry both energy and momentum as they propagate through space

33 In the network shown,



(a) the potential difference across D_2 is 5 V
(b) current through resistor equals 2.25 A
(c) current through diode D_1 and resistance is 1.25 A
(d) current through diode D_2 and resistance is 1.25 A

34 The work done in blowing a soap bubble of surface tension 0.06 Nm^{-1} from 2 cm radius to 5 cm radius is

(a) 0.004168 J (b) 0.003168 J
(c) 0.003158 J (d) 0.004568 J

35 A body is dropped from a height h. If t_1 and t_2 be the times in covering first half and the next half distances respectively, then the relation between t_1 and t_2 is

(a) $t_1 = t_2$ (b) $t_1 = 2t_2$ (c) $t_1 = 3t_2$ (d) $t_1 = \frac{t_2}{(\sqrt{2}-1)}$

Section-B

36 Eight equal drops of water are falling through air with a steady velocity of 10 cms^{-1}. If the drops combine to form a single drop big in size, then the terminal velocity of this big drop is

(a) 80 cms^{-1} (b) 30 cms^{-1}
(c) 10 cms^{-1} (d) 40 cms^{-1}

37 Two rings of the same radius and mass are placed, such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to the plane of one of the rings is (mass of ring $= m$ and radius $= r$)

(a) $\frac{1}{2}mr^2$ (b) mr^2
(c) $\frac{3}{2}mr^2$ (d) $2mr^2$

38 **Statement I** Kinetic friction is used in stopping relative motion by using brakes in machines and automobiles.
Statement II We are able to walk because of static friction.

(a) Both statement I and statement II are true.
(b) Both statement I and statement II are false.
(c) Statement I is true but statement II is false.
(d) Statement I is false but statement II is true.

39. The ratio of the kinetic energy required to be given to the satellite to escape the earth's gravitational field to the kinetic energy required to be given, so that the satellite moves in circular orbit just above earth's atmosphere, is

(a) one (b) two (c) half (d) infinity

40 The velocity of a particle in SHM varies with time as

$$v(t_{eq}) = (\sin 6t - \cos 6t)\,ms^{-1}$$

The maximum acceleration of the particle in ms^{-2} is

(a) $12\sqrt{2}$ (b) $6\sqrt{2}$
(c) 6 (d) 12

41 One mole of an ideal diatomic gas is heated from 20°C to 60°C at a constant pressure of 1 atm. The change in internal energy of the gas is nearby ($R = 8.31$ $Jmol^{-1}K^{-1}$)

(a) 561 J (b) 712 J
(c) 831 J (d) 1013 J

42 The frequency of a note emitted by a source changes by 20% as it approaches an observer. As it recedes away from him, the apparent frequency will differ from the actual frequency by

(a) 20% (b) 16.67%
(c) 14.3% (d) 19.4%

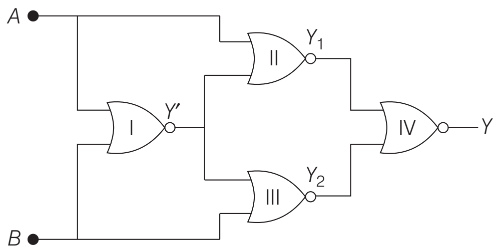
43 A spherical droplet having a potential of 2.5 V is obtained as a result of merging of 125 identical droplets. Find the potential of constituent droplet.

(a) 0.4 V (b) 0.5 V (c) 0.2 V (d) 0.1 V

44 Charge q of mass m is placed in a uniform electric field E, then kinetic energy after time t

(a) $\frac{qEt}{2m}$ (b) $\frac{qE^2t^2}{2m}$ (c) $\frac{2m}{q^2E^2t^2}$ (d) $\frac{q^2E^2t^2}{2m}$

45 A system of four gates is set up as shown. The 'truth table' corresponding to this system is



(a)

Input		Output
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

(b)

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

(c)

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(d)

Input		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

46 **Statement I** For higher temperatures, the peak emission wavelength of a black body shifts to lower wavelengths.
Statement II Peak emission wavelength of a black body is proportional to the four power of temperature.

(a) Both statement I and statement II are true.
(b) Both statement I and statement II are false.
(c) Statement I is true but statement II is false.
(d) Statement I is false but statement II is true.

47 **Assertion** For insulators and semiconductors, number of electrons increases with increasing temperature.
Reason This increase of number of electrons is more effective than any decrease in τ, so that for such materials ρ decreases with temperature.

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c) Assertion is true but Reason is false.
(d) Assertion is false but Reason is true.

48 Match the following columns and choose the correct code.

Column I (Rotation of different bodies)		Column II (Their moment of inertia)	
A.	Thin circular ring of radius R having axis perpendicular to the plane and passing through units	1.	$MR^2/2$
B.	Thin circular ring of radius R having axis passing through its diameter	2.	$ML^2/12$
C.	Thin rod of length L about an axis perpendicular to the rod and passing through mid-point	3.	MR^2
D.	Circular disc of radius R about an axis perpendicular to the disc and passing through the centre.	4.	$MR^2/4$

Codes

	A	B	C	D		A	B	C	D
(a)	3	2	2	1	(b)	2	3	1	2
(c)	3	1	2	1	(d)	3	1	2	4

49 Two magnets, the magnetic moment of one being twice that of other, oscillate in a magnetic field first with like poles tied together and then with unlike poles tied together. The ratio of the time periods in the two cases, is

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

50 When an electron in hydrogen atom is excited, from its 4th to 5th stationary orbit, the change in angular momentum of electron is (Planck's constant $h = 6.6\times 10^{-34}$ J-s)

(a) 4.16×10^{-34} J-s
(b) 3.32×10^{-34} J-s
(c) 1.05×10^{-34} J-s
(d) 2.08×10^{-34} J-s

Answers

1	(d)	2	(b)	3	(b)	4	(d)	5	(c)	6	(b)	7	(c)	8	(a)	9	(c)	10	(c)
11	(a)	12	(a)	13	(c)	14	(a)	15	(d)	16	(c)	17	(d)	18	(a)	19	(b)	20	(c)
21	(c)	22	(b)	23	(b)	24	(d)	25	(b)	26	(d)	27	(d)	28	(d)	29	(c)	30	(b)
31	(a)	32	(d)	33	(c)	34	(b)	35	(d)	36	(d)	37	(c)	38	(a)	39	(a)	40	(b)
41	(c)	42	(c)	43	(d)	44	(d)	45	(a)	46	(c)	47	(b)	48	(c)	49	(b)	50	(c)

Hints and Explanations

1 Out of given choices, (a) is exponential equation and (b) is trigonometric function and we know that, dimensional analysis fails to derive physical relations involving logarithmic, trigonometric and exponential functions. Now, choice (c) is the equation having two terms added by an operation '+', it also cannot be derived by dimensional analysis, so choice (d) is the answer.

2 $\therefore \cos\theta = \frac{\mathbf{A}\cdot\mathbf{B}}{AB}$

$$= \frac{(\hat{i}+\hat{j})\cdot(\hat{i}-\hat{j})}{\sqrt{1^2+1^2}\times\sqrt{1^2+(-1)^2}}$$

$$= \frac{1-1}{2} = 0 = \cos 90^\circ \Rightarrow \theta = 90^\circ$$

3 The distance covered by the body in **n**th second,

$$s_n = u + \frac{1}{2}a(2n-1)$$

Here, the body starts from rest, so $u = 0$.

$$\therefore \quad s_n = \frac{1}{2}a(2n-1) \quad \text{...(i)}$$

Distance covered by the body in n second,

$$s = un + \frac{1}{2}an^2$$

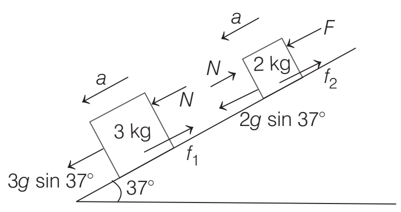
Again, $u = 0,\ s = \frac{1}{2}an^2$ ...(ii)

$$\text{Required ratio} = \frac{s_n}{s} = \frac{\frac{1}{2}a(2n-1)}{\frac{1}{2}an^2}$$

$$= \frac{2n-1}{n^2}$$

4 When a ball is dropped from the window of a train, then acceleration due to gravity **g** (in vertically downward direction) acts on it, so it moves on a parabola with acceleration **g** (projectile situation).

5 The free body diagram of two blocks are shown in figure.



Under the assumption that both blocks is moving together,

$$F + 2g\sin 37^\circ + 3g\sin 37^\circ - f_1 - f_2 = 5a$$

where, $f_1 = \mu \times 3g\cos 37^\circ$

and $f_2 = \mu \times 2g\cos 37^\circ \Rightarrow a = \frac{46}{5}\ \text{ms}^{-2}$

For 3 kg block,

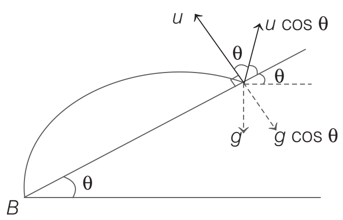
$N + 3g\sin 37^\circ - f_1 = 3a \Rightarrow N = 12$ N

6 As per figure in $\mathbf{u} = a\hat{i} + b\hat{j}$, both a and b are positive. In $\mathbf{v} = p\hat{i} + q\hat{j}$ $= p\hat{i} + (-q)(-\hat{j})$. So, p is positive and q is negative. Thus, a, b and p are positive and q is negative.

7 Time of flight, $T = \frac{2u}{g\cos\theta}$

We know that, range

$$= \frac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$$



Here, $\alpha - \beta = 90^\circ\ \{\beta = \theta\}$

$$\Rightarrow AB = \frac{2u^2\sin 90^\circ\cos(90^\circ+\theta)}{g\cos^2\theta}$$

$$\text{or}\quad AB = \frac{2u^2\cos(90^\circ+\theta)}{g\cos^2\theta}$$

$$\text{or}\quad AB = \frac{2u}{g\cos\theta}\cdot u\frac{\sin\theta}{\cos\theta} = Tu\tan\theta$$

8 $\therefore$ Angular velocity, $\omega = \alpha - \beta t$

$$\therefore \quad \frac{d\theta}{dt} = (\alpha - \beta t)$$

$$d\theta = (\alpha - \beta t)\,dt$$

When $\omega = 0$, then $t = \frac{\alpha}{\beta}$

$$\therefore \int_0^{\theta} d\theta = \int_0^{\alpha/\beta}(\alpha - \beta t)\,dt$$

$$\theta = \alpha[t]_0^{\alpha/\beta} - \beta\left(\frac{t^2}{2}\right)_0^{\alpha/\beta}$$

$$= \alpha\left(\frac{\alpha}{\beta}\right) - \frac{\beta}{2}\left(\frac{\alpha^2}{\beta^2}\right) = \frac{\alpha^2}{\beta} - \frac{\alpha^2}{2\beta} = \frac{\alpha^2}{2\beta}$$

9 Orbital velocity of satellite at distance **r** from the centre of earth is, $v = \sqrt{\frac{GM}{r}}$.

Total energy of satellite,

$$TE = PE + KE = -\frac{GMm}{r} + \frac{1}{2}mv^2$$

$$= -\frac{GMm}{r} + \frac{1}{2}m\frac{GM}{r} = -\frac{GMm}{2r}$$

The viscous force acting on satellite decreases the energy of satellite. As a result of it, the value of speed gradually decreases, consequently the height of satellite gradually decreases.

10 Let the equation of simple harmonic motion be

$x = A\cos\omega t,\ v = -A\omega\sin\omega t,$

where $\omega = \frac{2\pi}{T}$

And time interval $= \frac{T}{6}$

Mean velocity over the required interval is

$$v_{\text{mean}} = \frac{\int_0^{T/6} v\,dt}{T/6}$$

$$v_{\text{mean}} = \frac{\int_0^{T/6} -A\omega\sin\omega t\,dt}{T/6}$$

$$= \frac{6A}{T}\times[\cos\omega t]_0^{T/6} = \frac{3A}{T}$$

11 Kinetic energy per unit volume for a gas

$$\frac{E}{V} = \frac{3}{2}p$$

where, p is the pressure applied by the gas.

Here, both the gases have same volume, so

$$E \propto p$$

$$\frac{E_{He}}{E_{N_2}} = \frac{p_{He}}{p_{N_2}}$$

$$\Rightarrow \frac{1500}{E_{N_2}} = \frac{p}{2p}$$

$$\Rightarrow E_{N_2} = 3000\ \text{J}$$

12 As latent heat of steam goes to melt the ice, $540 \times 10 = m \times 80$

$$\therefore \quad m = \frac{540}{8} = 67.5 = 68\ \text{g}$$

Now, amount of water

$$= 500 + 68 + 10 = 578\ \text{g}$$

13 The rate of loss of heat from the ball,

$$E = Ae\sigma(T^4 - T_0^4)$$

Here, $A = 200\ \text{cm}^2 = 200\times 10^{-4}\ \text{m}^2$,

$$e = 0.4,\ \sigma = 5.67\times 10^{-8}\ \frac{\text{J}}{\text{m}^2\text{sK}^4}$$

$T = 527^\circ\text{C} = 527 + 273 = 800$ K

$T_0 = 27^\circ\text{C} = 27 + 273 = 300$ K

$$\therefore E = 200\times 10^{-4}\times 0.4\times 5.67\times 10^{-8} \times\{(800)^4 - (300)^4\}$$

$$= 200\times 10^{-4}\times 0.4\times 5.67\{4096 - 81\}$$

$$= 0.8\times 5.67\times 4015\times 10^{-2}$$

$$= 182\ \text{Js}^{-1}$$

14 A. The magnetic flux through the rectangular loop **abcd** increases, due to the motion of the loop into the region of magnetic field. Thus, the induced current must flow along the path **bcdab**, so that it opposes the increasing flux.

B. Due to the outward motion, magnetic flux through the triangular loop **abc** decreases. Thus, the induced current must flow along **bacb**, so as to oppose the change in flux.

C. As the magnetic flux decreases due to the motion of the irregular shaped loop **abcd** out of the region of magnetic field, the induced current flows along **cdabc**, so as to oppose the change in flux.

Hence, A → 3, B → 1 and C → 2.

15 ∴ Intensity of sound, $I \propto \frac{1}{r^2}$

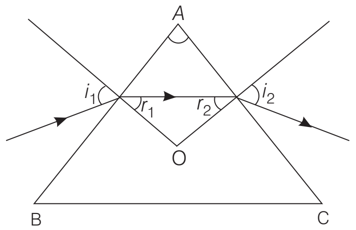
$$\therefore \frac{I_P}{I_Q} = \frac{(25)^2}{(9)^2} \text{ and amplitude}^2 \propto \text{intensity}$$

$$\frac{A_P^2}{A_Q^2} = \frac{I_P}{I_Q}$$

$$\Rightarrow \frac{A_P}{A_Q} = \sqrt{\frac{I_P}{I_Q}} \Rightarrow \frac{A_P}{A_Q} = \sqrt{\frac{(25)^2}{(9)^2}}$$

$$\therefore \frac{A_P}{A_Q} = \frac{25}{9}$$

16 From law of refraction,



$$\mu = \frac{\sin i_1}{\sin r_1}$$

Here, μ = refractive index of material of prism.

So, $i_1 \propto r_1$

Maximum value of i_1 is 90°. If i_1 is 90°, then $r_1 = C$, critical angle at the other surface of the prism. Also, there will be no emergent rays, if the angle of incidence at surface *AC* is more than the critical angle, i.e. $r_2 > C$.

Angle of prism, $A = r_1 + r_2$

$$A = C + r_2$$

Here, $r_2 > C$

So, $A > 2C$

17 For microscope, limit of resolution is proportional to the wavelength of light used,

i.e. $d \propto \lambda$

$$\frac{d_1}{d_2} = \frac{\lambda_1}{\lambda_2}$$

$$\frac{0.1}{d_2} = \frac{6000}{4800} \Rightarrow \frac{0.1}{d_2} = \frac{5}{4}$$

$$\Rightarrow d_2 = \frac{0.4}{5} = 0.08 \text{ mm}$$

18 Here, the ball is charged in sinusoidal manner, so charge on the ball at any instant, $q = q_0 \sin \omega t$

where, q_0 = maximum charge.

Displacement current,

$$I_d = \frac{dq}{dt} = \frac{d}{dt}[q_0 \sin \omega t]$$

$$= q_0 \cos \omega t . \omega = q_0 \omega \cos \omega t$$

For maximum displacement current,

$$\cos \omega t = 1$$

$$\therefore (I_d)_{max} = q_0 \omega$$

$$= 10^{-6} \times 2\pi \times 10^6$$

$$= 2\pi = 6.28 \text{ A}$$

19 Maximum amount of charge hold by first capacitor,

$$q_1 = C_1 V_1 = 1 \times 10^{-6} \times 6 \times 10^3$$

$$= 6000 \ \mu C$$

Similarly, $q_2 = C_2 V_2$

$$= 2 \times 10^{-6} \times 4 \times 10^3 = 8000 \ \mu C$$

In series order, charge on both the capacitors is same and is the least value. So, in series combination of above two capacitors, the charge should be **6000** μC.

∴ Voltage on first capacitor $V_1 = \frac{q}{C_1}$

$$= \frac{6000}{1} = 6000 \text{ V} = 6 \text{ kV}$$

Similarly, $V_2 = \frac{q}{C_2} = \frac{6000}{2} = 3000 \text{ V}$

$$= 3 \text{ kV}$$

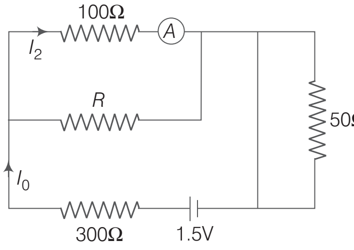
Voltage on the system,

$$V = V_1 + V_2 = 6 + 3 = 9 \text{ kV}$$

20 When both switches are open, ammeters reading

$$I_1 = \frac{1.5}{300 + 100 + 50}$$

When both switches are closed, circuit would be as shown



$$I_0 = \frac{1.5}{300 + \frac{100R}{100 + R}}$$

Ammeter reading is

$$I_2 = \frac{I_0 \times R}{100 + R} = \frac{1.5R}{300(100 + R) + 100R}$$

As, $I_1 = I_2$ which gives $R = 600 \ \Omega$.

21 Resistance of heater is given by

$$R_H = \frac{V^2}{P} = \frac{100 \times 100}{1000} = 10 \ \Omega$$

If heater dissipates 62.5 W, then voltage across, it is given by

$$(V')^2 = 62.5 \times R_H = 62.5 \times 10$$

$$\Rightarrow V' = 25 \text{ V}$$

The remaining 75 V should drop across 10 Ω resistance. In other words, current **I** in the circuit should be 7.5 A. It is clear from the circuit that

$$I = I_H + I_R \text{ or } I = \frac{V_H}{R_H} + \frac{V_R}{R}$$

Substituting,

$I = 7.5$ A, $V_H = V_R = 25$ V and $R_H = 10 \ \Omega$, we get $R = 5 \ \Omega$

22 Heat produced by kettle, $H = \frac{V^2}{R} t$.

Here, heat taken by the water in both conditions, is same and voltage across the kettle is also same. So,

$$t \propto R \text{ or } \frac{t_1}{t_2} = \frac{R_1}{R_2}$$

Resistance of the kettle is directly proportional to the number of turns in the coil.

So, $\frac{t_1}{t_2} = \frac{n_1}{n_2}$

$$\Rightarrow \frac{16}{t_2} = \frac{100}{90}$$

$$\Rightarrow t_2 = \frac{16 \times 90}{100} = 14.4 \text{ min}$$

23 Magnetic field due to solenoid,

$B_1 = 4$ mT (along the axis)

Magnetic field due to a long straight wire,

$$B_2 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 20}{2\pi \times 3 \times 10^{-3}}$$

$$= \frac{4}{3} \times 10^{-3} \text{ T}$$

$$= \frac{4}{3} \text{ mT (perpendicular to the axis)}$$

So, resultant magnetic field,

$$B = \sqrt{B_1^2 + B_2^2} = \sqrt{4^2 + \left(\frac{4}{3}\right)^2} = 4.2 \text{ mT}$$

24 As, $\Delta Q = ms\Delta\theta$ [for water]

$$= 50 \times s \times 5$$

$$\Rightarrow \left(\frac{dQ}{dt}\right)_1 = \text{rate of cooling}$$

$$= \frac{250}{2 \times 60} = \frac{25}{12}$$

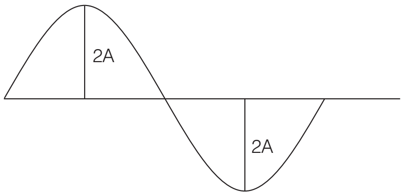
$[\because s_w = 1 \text{ cal/g}]$

Now, other liquid $\left(\frac{dQ}{dt}\right)_s$ = rate of cooling $= \frac{100 \times s \times 5}{2 \times 60} = \frac{50s}{12}$

Now, $\left(\frac{dQ}{dt}\right)_l = \left(\frac{dQ}{dt}\right)_s$

$\Rightarrow \quad s = 0.5 \text{ cal/g} = 0.5 \text{ kcal/kg}$

25 Frequency = 50 Hz



$\therefore$ Time period $T = \frac{1}{50}$ s

Rate of change of current

$$\frac{dI}{dt} = \frac{I_2 - I_1}{T/2} = \frac{2-(-2)}{\frac{1}{100}}$$

$= 4 \times 100 = 400 \text{ A s}^{-1}$

Crest value of voltage across secondary,

$$e_s = M\frac{dI}{dt}$$

$= 0.25 \times 400$

$= 100$ V

26 Given, $V = 220$ V and $V_L = 176$ V

For *L-R* circuit, $V^2 = V_L^2 + V_R^2$

$$V_R = \sqrt{V^2 - V_L^2}$$

$= \sqrt{(220)^2 - (176)^2}$ V

27 Here, $Y_c = 1 \times 10^{11}$ N/m² and

$Y_s = 2 \times 10^{11}$ N/m²

$l_c = 1.0$ m, $l_s = 0.5$ m

and $\Delta l_c = 1 \times 10^{-3}$ m

As, $\quad (\text{Strain})_c = \frac{\text{Stress}}{Y_c}$

$\Rightarrow \quad 1 \times 10^{-3} = \frac{\text{Stress}}{1 \times 10^{11}}$

$\Rightarrow$ Stress $= 10^8$ N/m²

Now, $\quad Y_s = \frac{\text{Stress}}{\text{Strain}}$

$\Rightarrow$ Stress $= \frac{10^8}{2 \times 10^{11}} = 0.5 \times 10^{-3}$

or $\quad \frac{\Delta l_s}{1/2} = 0.5 \times 10^{-3}$

$\Rightarrow \quad \Delta l_s = 0.25 \times 10^{-3}$

$\therefore \quad \Delta l = \Delta l_c + \Delta l_s$

$= 1 + 0.25 = 1.25$ mm

28 As we know that, $\frac{M}{B_H} \cdot \frac{4\pi}{\mu_0}(r^2 + l^2)^{3/2}$

$\because \quad l << r$, so $B_H = \frac{\mu_0}{4\pi} = \frac{M}{r^3}$

which gives B_H at equator ≈ 0.32 gauss

29 $A_1 = N_1\lambda$ and $A_2 = N_2\lambda$

where, λ is disintegration constant.

For time $(t_2 - t_1)$,

$$A_1 - A_2 = (N_1 - N_2)\lambda$$

Number of atoms disintegrated in time $(t_2 - t_1)$ s,

$$(N_1 - N_2) = \frac{(A_1 - A_2)}{\lambda}$$

But $\lambda = \frac{1}{T}$, where T = mean life.

$\therefore \quad (N_1 - N_2) = (A_1 - A_2)T$

30 Let retina receives **n** photons per second.

So, $\quad nh\nu = 1.7 \times 10^{-18}$

or $\quad nh\frac{c}{\lambda} = 1.7 \times 10^{-18}$

$\therefore \quad n = 1.7 \times 10^{-18} \times \frac{\lambda}{hc}$

$$n = \frac{1.7 \times 10^{-18} \times 6000 \times 10^{-10}}{6.6 \times 10^{-34} \times 3 \times 10^8} \simeq 5$$

31 Wavelength of Balmer series is given by

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{\nu}{c} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad [\because c = \nu\lambda]$$

$$\nu = cR\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

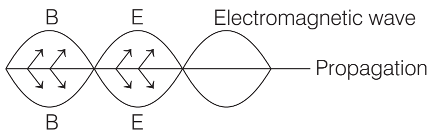
For second line of Balmer series,

$n_1 = 2$; $n_2 = 4$

$$\nu = 3 \times 10^8 \times 10967800\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$= 6.16 \times 10^{14}$ Hz

32



As electromagnetic wave contains both electric field and magnetic field. It carry both energy and momentum according to de-Broglie, wave particle duality of radiations.

33 D_1 is forward biased and D_2 reverse biased.

Therefore, current through the resistance and D_1 will be equal and which is equal to $\frac{5}{4} = 1.25$ A.

34 As given, $s = 0.06 \text{ Nm}^{-1}$

$r_1 = 2$ cm $= 0.02$ m,

$r_2 = 5$ cm $= 0.05$ m

Since, bubble has two surface.

Initial surface area of the bubble

$= 2 \times 4\pi r_1^2$

$= 2 \times 4\pi \times (0.02)^2 = 32\pi \times 10^{-4}$ m²

Final surface area of the bubble

$= 2 \times 4\pi r_2^2 = 2 \times 4 \times \pi \times (0.05)^2$

$= 200 \times \pi \times 10^{-4}$ m²

So, work done = s × increase in surface area

$= 0.06 \times (200 \times \pi \times 10^{-4} - 32\pi \times 10^{-4})$

$= 0.06 \times 168p \times 10^{-4} = 0.003168$ J

35 Time taken by the body in covering first half is t_1, so

$$\frac{h}{2} = \frac{1}{2}gt_1^2 \Rightarrow t_1^2 = \frac{h}{g} \Rightarrow t_1 = \sqrt{\frac{h}{g}}$$

For total journey,

$$h = \frac{1}{2}gt^2 \Rightarrow t^2 = \frac{2h}{g}$$

$$t^2 = 2t_1^2 \Rightarrow t = \sqrt{2}\,t_1$$

Time taken in covering next half,

$t_2 = t - t_1 = \sqrt{2}\,t_1 - t_1$

$= t_1(\sqrt{2} - 1)$

$\Rightarrow \quad t_1 = \frac{t_2}{(\sqrt{2} - 1)}$

36 We know that,

$$v \propto r^2 \quad \text{and} \quad 8\left(\frac{4}{3}\pi r_1^3\right) = \frac{4}{3}\pi r_2^3$$

$\therefore \quad \frac{v_1}{v_2} = \frac{r_1^2}{r_2^2} \Rightarrow \frac{10}{v_2} = \frac{r^2}{8^{2/3}r^2} = \frac{1}{4}$

$\Rightarrow \quad v_2 = 40$ cm/s

37 Moment of inertia of ring about the axis passing through its centre and in its plane $I_1 = \frac{1}{2}mr^2$

Moment of inertia of ring about the axis passing through its centre and perpendicular to its plane

$$I_2 = mr^2$$

$\therefore$ Moment of inertia of system,

$$I = I_1 + I_2 = \frac{1}{2}mr^2 + mr^2 = \frac{3}{2}mr^2$$

38 Both the statements are true as kinetic friction is used to stop relative motion by using brakes in machines and automobiles. Also, walking is possible because of static friction.

39 Kinetic energy of the satellite moving round the earth,

$$K_1 = \frac{1}{2}mv_o^2$$

where, v_o = orbital velocity of satellite.

Kinetic energy required to escape from the earth's gravitational field

$K_2 = \frac{1}{2} m v_e^2$

where, v_e = escape velocity.

We know that, $v_e = \sqrt{2} v_o$

$\therefore K_2 = \frac{1}{2} m (\sqrt{2} v_o)^2 = 2\left(\frac{1}{2} m v_o^2\right)$

$= 2K_1$

$\therefore$ Kinetic energy required to escape

$= K_2 - K_1 = 2K_1 - K_1 = K_1$

Required ratio $= \frac{K_2 - K_1}{K_1} = 1$

40 $v(t) = (\sin 6t - \cos 6t)$

Acceleration,

$a(t) = \frac{dv(t)}{dt} = \frac{d}{dt}[\sin 6t - \cos 6t]$

$= \cos 6t \times 6 - (-\sin 6t) \times 6$

$= 6[\cos 6t + \sin 6t]$

$= 6 \times \sqrt{2}\left(\frac{1}{\sqrt{2}} \cos 6t + \frac{1}{\sqrt{2}} \sin 6t\right)$

$= 6\sqrt{2}\left(\sin \frac{\pi}{4} \cos 6t + \cos \frac{\pi}{4} \sin 6t\right)$

$= 6\sqrt{2} \sin\left(\frac{\pi}{4} + 6t\right)$

For maximum acceleration,

$\sin\left(\frac{\pi}{4} + 6t\right) = 1.$

$\therefore \quad [a(t)]_{max} = 6\sqrt{2} \text{ ms}^{-2}$

41 Change in internal energy,

$dU = dQ - dW.$

dQ = amount of heat given at constant pressure

$= nC_p \Delta t = 1 \times \frac{7}{2} R \times (60 - 20) = 140 R$

dQ = work done at constant pressure

$= pdV = p\frac{R \Delta t}{P}$

$= R \Delta T = R(60 - 20) = 40 R$

$\therefore dU = 140R - 40R$

$= 100 R = 100 \times 8.31 = 831 J$

42 When source approaches the observer, then apparent frequency

$n' = \frac{v}{v - v_s} n$

where, v = velocity of sound,

v_s = velocity of source

Here, $n' = \frac{120 n}{100}$

$\therefore \frac{120n}{100} = \frac{v}{v - v_s} \times n$

$\Rightarrow \frac{6}{5} = \frac{v}{v - v_s}$

$6v - 6v_s = 5v \Rightarrow v_s = \frac{v}{6}$

Now, the source recedes away from observer,

so, $n'' = \frac{v}{v + v_s} n = \frac{v}{v + v/6} n = \frac{6}{7} n$

Per cent change $= \frac{n - n''}{n} \times 100$

$= \frac{\left(n - \frac{6}{7} n\right)}{n} \times 100 = 14.3\%$

43 Let the radii of bigger and smaller drops be **R** and **r**.

Volume of 125 small drops

= Volume of big drop

$\therefore \quad 125 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$

$\Rightarrow \quad 5r = R$

Potential on big drop $V = k \frac{nq}{R}$

Potential on small drop $V' = k \frac{q}{r}$

$V' = \frac{kq}{R/5} = k\left(\frac{5q}{R}\right)$

$V' = 5 \frac{V}{n} = 5 \times \frac{2.5}{125}$

$= \frac{2.5}{25} = 0.1 \text{ V}$

44 When charge **q** is placed in uniform electric field **E**, then its acceleration,

$a = \frac{qE}{m}$

So, its motion will be uniformly accelerated motion and its velocity after time **t** is given by,

$v = at = \frac{qE}{m} t$

$KE = \frac{1}{2} mv^2$

$= \frac{1}{2} m \left(\frac{qEt}{m}\right)^2 = \frac{q^2 E^2 t^2}{2m}$

45 Output of gate I is $Y' = \overline{A + B}$

Output of gate II is $Y_1 = \overline{A + Y'}$

Output of gate III is $Y_2 = \overline{B + Y'}$

Output of gate IV is $Y = \overline{Y_1 + Y_2}$

The truth table of the combination is in option (a).

46 According to Wien's law, the peak emission wavelength of a body is inversely proportional to its absolute temperature.

$\lambda_m T$ = constant

$\Rightarrow \quad \lambda_m = \frac{\text{constant}}{T}$

Higher T implies lower λ_m.

47 Resistivity of a material is given by

$\rho = \frac{1}{\sigma} = \frac{m}{ne^2 \tau}$

ρ thus depends inversely both on the number **n** of free electrons per unit volume and on the average time τ between collisions. For insulators and semiconductors, **n** increases with temperature.

This increase of **n** is more effective than any decrease in τ, so that for such materials ρ decreases with temperature.

Therefore, Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

48 A → 3, B → 1, C → 2, D → 1.

	Body	Moment of inertia
A.	Thin circular ring of radius R raving anis perpendicular to the plane and passing though units	1. MR^2
B.	Thin circular ring of radius R having axis passing throyh its diameter	2. $MR^2/2$
C.	Thin rod of length L about an axis perpendicular to the rod and passing through mid point	3. $ML^2/12$
D.	Circular disc of radius R about an axis perpendicular to the disc and passing through the untie.	4. $MR^2/2$

49 In sum position,

$T_1 = 2\pi \sqrt{\frac{I_1 + I_2}{(M_1 + M_2) H}}$

In difference position,

$T_2 = 2\pi \sqrt{\frac{I_1 + I_2}{(M_1 - M_2) H}}$

Therefore, $\frac{T_1}{T_2} = \frac{1}{\sqrt{3}}$

50 Change in angular momentum of electron,

$\Delta L = L_2 - L_1$

$= \frac{n_2 h}{2\pi} - \frac{n_1 h}{2\pi}$

or $\quad \Delta L = \frac{h}{2\pi}(n_2 - n_1)$

$= \frac{6.6 \times 10^{-34}}{2 \times 3.14}(5 - 4)$

$= 1.05 \times 10^{-34}$ J-s