SOLVED PAPER 2016

JEE Main

Instructions **Max. Marks 120**

- This test consists of 30 questions of equal weightage. Each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above in instruction no. 2 for correct response of each question. 1 mark will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

Physics

1. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90 s, 91 s, 92 s and 95 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be

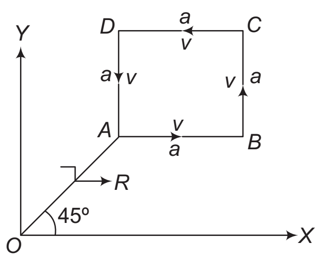
(a) (92 ± 2s)

(b) (92 ± 5 s)

(c) (92 ± 1.8s)

(d) (92 ± 3 s)

2. A particle of mass m is moving along the side of a square of side a, with a uniform speed v in the X-Y plane as shown in the figure.



Which of the following statements is **false** for the angular momentum **L** about the origin?

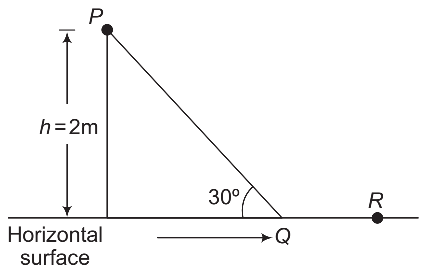
(a) $\mathbf{L} = \frac{-mv}{\sqrt{2}} R\hat{\mathbf{k}}$ when the particle is moving from A to B

(b) $\mathbf{L} = mv\left(\frac{R}{\sqrt{2}} - a\right)\hat{\mathbf{k}}$ when the particle is moving from C to D

(c) $\mathbf{L} = mv\left(\frac{R}{\sqrt{2}} + a\right)\hat{\mathbf{k}}$ when the particle is moving from B to C

(d) $\mathbf{L} = \frac{mv}{\sqrt{2}} R\hat{\mathbf{k}}$ when the particle is moving from D to A

3. A point particle of mass m, moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released from rest, from the point P and it comes to rest at a point R. The energies lost by the ball, over the parts PQ and QR of the track, are equal to each other, and no energy is lost when particle changes direction from PQ to QR. The values of the coefficient of friction μ and the distance x (= QR), are respectively close to

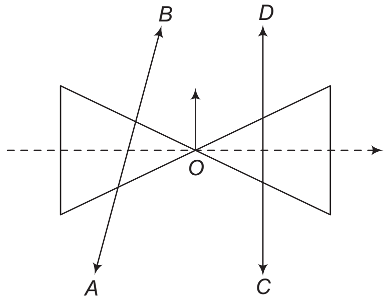


(a) 0.2 and 6.5 m
(b) 0.2 and 3.5 m
(c) 0.29 and 3.5 m
(d) 0.29 and 6.5 m

4. A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies 3.8×10^7 J of energy per kg which is converted to mechanical energy with a 20% efficiency rate. (Take, $g = 9.8 \text{ ms}^{-2}$)

(a) 2.45×10^{-3} kg
(b) 6.45×10^{-3} kg
(c) 9.89×10^{-3} kg
(d) 12.89×10^{-3} kg

5. A roller is made by joining together two corners at their vertices O. It is kept on two rails AB and CD which are placed asymmetrically (see the figure), with its axis perpendicular to CD and its centre O at the centre of line joining AB and CD (see the figure). It is given a light push, so that it starts rolling with its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to



(a) turn left
(b) turn right
(c) go straight
(d) turn left and right alternately

6. A satellite is revolving in a circular orbit at a height h from the Earth's surface (radius of earth $R, h << R$). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to (Neglect the effect of atmosphere)

(a) $\sqrt{2gR}$ (b) $\sqrt{gR}$
(c) $\sqrt{gR/2}$ (d) $\sqrt{gR}\,(\sqrt{2}-1)$

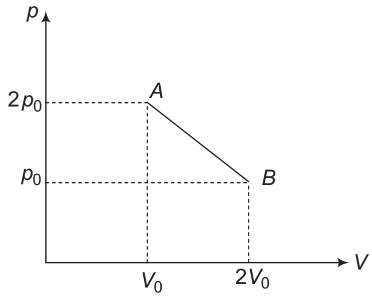
7. A pendulum clock loses 12 s a day if the temperature is 40°C and gains 4 s a day if the temperature is 20°C. The temperature at which the clock will show correct time, and the coefficient of linear expansion α of the metal of the pendulum shaft are, respectively.

(a) 25°C, $\alpha = 1.85 \times 10^{-5}/°C$
(b) 60°C, $\alpha = 1.85 \times 10^{-4}/°C$
(c) 30°C, $\alpha = 1.85 \times 10^{-3}/°C$
(d) 55°C, $\alpha = 1.85 \times 10^{-2}/°C$

8. An ideal gas undergoes a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure p and volume V is given by pV^n = constant, then n is given by (Here, C_p and C_V are molar specific heat at constant pressure and constant volume, respectively)

(a) $n = \frac{C_p}{C_V}$ (b) $n = \frac{C - C_p}{C - C_V}$
(c) $n = \frac{C_p - C}{C - C_V}$ (d) $n = \frac{C - C_V}{C - C_p}$

9. n moles of an ideal gas undergoes a process A and B as shown in the figure. The maximum temperature of the gas during the process will be



(a) $\frac{9}{4}\frac{p_0V_0}{nR}$ (b) $\frac{3}{2}\frac{p_0V_0}{nR}$
(c) $\frac{9}{2}\frac{p_0V_0}{nR}$ (d) $\frac{9p_0V_0}{nR}$

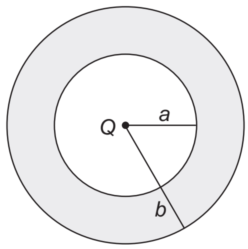
10. A particle performs simple harmonic motion with amplitude A. Its speed is trebled at the instant that it is at a distance $\frac{2}{3}A$ from equilibrium position. The new amplitude of the motion is

(a) $\frac{A}{3}\sqrt{41}$ (b) $3A$
(c) $A\sqrt{3}$ (d) $\frac{7}{3}A$

11. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is (Take, $g = 10\text{ ms}^{-2}$)

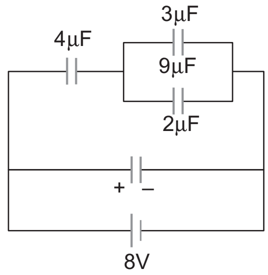
(a) $2\pi\sqrt{2}$ s (b) 2 s
(c) $2\sqrt{2}$ s (d) $\sqrt{2}$ s

12. The region between two concentric spheres of radii a and b, respectively (see the figure), has volume charge density $\rho = \frac{A}{r}$, where, A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A, such that the electric field in the region between the spheres will be constant, is



(a) $\frac{Q}{2\pi a^2}$ (b) $\frac{Q}{2\pi(b^2 - a^2)}$
(c) $\frac{2Q}{\pi(a^2 - b^2)}$ (d) $\frac{2Q}{\pi a^2}$

13. A combination of capacitors is set-up as shown in the figure. The magnitude of the electric field, due to a point charge Q (having a charge equal to the sum of the charges on the 4 μF and 9μF capacitors), at a point distant 30 m from it, would equal to



(a) 240 N/C (b) 360 N/C
(c) 420 N/C (d) 480 N/C

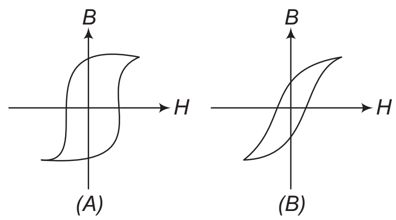
14. The temperature dependence of resistances of Cu and undoped Si in the temperature range 300-400 K, is best described by

(a) linear increase for Cu, linear increase for Si
(b) linear increase for Cu, exponential increase for Si
(c) linear increase for Cu, exponential decrease for Si
(d) linear decrease for Cu, linear decrease for Si

15. Two identical wires A and B, each of length l, carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side a. If B_A and B_B are the values of magnetic field at the centres of the circle and square respectively, then the ratio $\frac{B_A}{B_B}$ is

(a) $\frac{\pi^2}{8}$ (b) $\frac{\pi^2}{16\sqrt{2}}$ (c) $\frac{\pi^2}{16}$ (d) $\frac{\pi^2}{8\sqrt{2}}$

16. Hysteresis loops for two magnetic materials A and B are as given below:



These materials are used to make magnets for electric generators, transformer core and electromagnet core. Then, it is proper to use

(a) A for electric generators and transformers
(b) A for electromagnets and B for electric generators
(c) A for transformers and B for electric generators
(d) B for electromagnets and transformers

17. An arc lamp requires a direct current of 10 A at 80 V to function. If it is connected to a 220 V (rms), 50 Hz AC supply, the series inductor needed for it to work is close to

(a) 80 H (b) 0.08 H
(c) 0.044 H (d) 0.065 H

18. Arrange the following electromagnetic radiations in the order of increasing energy.

A. Blue light B. Yellow light
C. X-ray D. Radio wave

(a) D, B, A, C (b) A, B, D, C
(c) C, A, B, D (d) B, A, D, C

19. An observer looks at a distant tree of height 10 m with a telescope of magnifying power of 20. To observer the tree appears

(a) 10 times taller (b) 10 times nearer
(c) 20 times taller (d) 20 times nearer

20. The box of a pin hole camera of length L, has a hole of radius a. It is assumed that when the hole is illuminated by a parallel beam of light of wavelength λ the spread of the spot (obtained on the opposite wall of the camera) is the sum of its geometrical spread and the spread due to diffraction. The spot would then have its minimum size (say b_{min}) when

(a) $a = \frac{\lambda^2}{L}$ and $b_{min} = \left(\frac{2\lambda^2}{L}\right)$

(b) $a = \sqrt{\lambda L}$ and $b_{min} = \left(\frac{2\lambda^2}{L}\right)$

(c) $a = \sqrt{\lambda L}$ and $b_{min} = \sqrt{4\lambda L}$

(d) $a = \frac{\lambda^2}{L}$ and $b_{min} = \sqrt{4\lambda L}$

21. Radiation of wavelength λ, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be

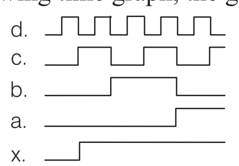
(a) $> v\left(\frac{4}{3}\right)^{1/2}$ (b) $< v\left(\frac{4}{3}\right)^{1/2}$

(c) $= v\left(\frac{4}{3}\right)^{1/2}$ (d) $= v\left(\frac{3}{4}\right)^{1/2}$

22. Half-lives of two radioactive elements A and B are 20 min and 40 min, respectively. Initially, the samples have equal number of nuclei. After 80 min, the ratio of decayed numbers of A and B nuclei will be

(a) 1 : 16 (b) 4 : 1
(c) 1 : 4 (d) 5 : 4

23. If a, b, c and d are inputs to a gate and x is its output, then, as per the following time graph, the gate is



(a) NOT (b) AND
(c) OR (d) NAND

24. Choose the correct statement:

(a) In amplitude modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal
(b) In amplitude modulation, the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal
(c) In frequency modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal
(d) In frequency modulation, the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal

25. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet, if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line?

(a) 0.75 mm
(b) 0.80 mm
(c) 0.70 mm
(d) 0.50 mm

26. A pipe open at both ends has a fundamental frequency f in air. The pipe is dipped vertically in water, so that half of it is in water. The fundamental frequency of the air column is now

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

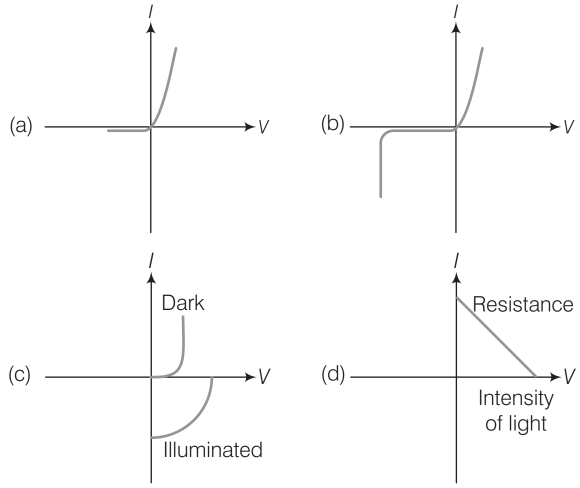
27. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection when a current of 1 mA is passed through it. The value of the resistance which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is

(a) 0.01 Ω (b) 2 Ω
(c) 0.1 Ω (d) 3 Ω

28. In an experiment for determination of refractive index of glass of a prism by i-δ plot, it was found that a ray incident at an angle 35° suffers a deviation of 40° and that it emerges at an angle 79°. In that case, which of the following is closest to the maximum possible value of the refractive index?

(a) 1.5 (b) 1.6 (c) 1.7 (d) 1.8

29. Identify the semiconductor devices whose characteristics are as given below, in the order (a),(b),(c),(d).



(a) Simple diode, Zener diode, Solar cell, Light dependent resistance
(b) Zener diode, Simple diode, Light dependent resistance, Solar cell
(c) Solar cell, Light dependent resistance, Zener diode, Simple diode
(d) Zener diode, Solar cell, Simple diode, Light dependent resistance

30. For a common-emitter configuration, if α and β have their usual meanings, the **incorrect** relationship between α and β is

(a) $\frac{1}{\alpha} = \frac{1}{\beta} + 1$ (b) $\alpha = \frac{\beta}{1-\beta}$
(c) $\alpha = \frac{\beta}{1+\beta}$ (d) $\alpha = \frac{\beta^2}{1+\beta^2}$

Answer *with* Explanations

1. *(a)* True value $= \frac{90+91+95+92}{4} = 92$

Mean absolute error $= \frac{|92-90|+|92-91|+|92-95|+|92-92|}{4}$

$= \frac{2+1+3+0}{4} = 1.5$

Value $= (92 \pm 1.5)$

Since, least count is 1 sec

$\therefore$ Value $= (92 \pm 2\text{s})$

2. *(b, d)* We can apply $\mathbf{L} = m(\mathbf{r} \times \mathbf{v})$ for different parts.

For example :

In part (a), co-ordinates of A are $\left(\frac{R}{\sqrt{2}}, \frac{R}{\sqrt{2}}\right)$

Therefore, $\mathbf{r} = \frac{R}{\sqrt{2}}\hat{\mathbf{i}} + \frac{R}{\sqrt{2}}\hat{\mathbf{j}}$ and $\mathbf{v} = v\hat{\mathbf{i}}$

So, substituting in $\mathbf{L} = m(\mathbf{r} \times \mathbf{v})$ we get,

$$\mathbf{L} = -\frac{mvR}{\sqrt{2}}\hat{\mathbf{k}}$$

Hence, option (a) is correct. Similarly, we can check other options also.

3. *(c)* As energy loss is same, thus

$$\mu mg\cos\theta \cdot (PQ) = \mu mg \cdot (QR)$$

$\therefore$ $QR = (PQ)\cos\theta$

$\Rightarrow$ $QR = 4 \times \frac{\sqrt{3}}{2} = 2\sqrt{3} \approx 3.5$ m

Further,

decrease in potential energy = loss due to friction

$\therefore$ $mgh = (\mu mg\cos\theta)d_1 + (\mu mg)d_2$

$$m \times 10 \times 2 = \mu \times m \times 10 \times \frac{\sqrt{3}}{2} \times 4 + \mu \times m \times 10 \times 2\sqrt{3}$$

$\Rightarrow$ $4\sqrt{3}\,\mu = 2$

$\Rightarrow$ $\mu = \frac{1}{2\sqrt{3}} = 0.288 = 0.29$

4. *(d)* Work done in lifting mass $= (10 \times 9.8 \times 1) \times 1000$

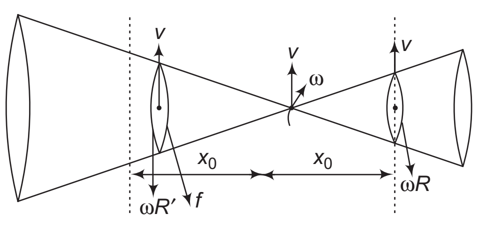
If m is mass of fat burnt, then energy

$$= m \times 3.8 \times 10^7 \times \frac{20}{100}$$

Equating the two, we get

$\therefore$ $m = \frac{49}{3.8} \approx 12.89 \times 10^{-3}$kg

5. *(a)*



At distance x_0 from O, $v = \omega R$

distance less than x_0, $v > \omega R$

Initially, there is pure rolling at both the contacts. As the cone moves forward, slipping at AB will start in forward direction, as radius at left contact decreases.

Thus, the cone will start turning towards left. As it moves further slipping at CD will start in backward direction which will also turn the cone towards left.

6. *(d)* $v_{\text{orbital}} = \sqrt{\frac{GM}{R}} = \sqrt{gR}$

$v_{\text{escape}} = \sqrt{2gR}$

$\therefore$ Extra velocity required

$= v_{\text{escape}} - v_{\text{orbital}}$

$= \sqrt{gR}\,(\sqrt{2}-1)$

7. *(a)* $T_0 = 2\pi\sqrt{\frac{L}{g}}$

$$T' = T_0 + \Delta T = 2\pi\sqrt{\frac{L+\Delta L}{g}}$$

$\therefore$ $T' = T_0 + \Delta T$

$= 2\pi\sqrt{\frac{L(1+\alpha\Delta\theta)}{g}}$

$= \left\{2\pi\sqrt{\frac{L}{g}}\right\}(1+\alpha\Delta\theta)^{\frac{1}{2}}$

$\approx T_0\left(1+\frac{\alpha\Delta\theta}{2}\right)$

$\therefore$ $\Delta T = T' - T_0 = \frac{\alpha\Delta\theta T_0}{2}$ ...(i)

or $\frac{\Delta T_1}{\Delta T_2} = \frac{\alpha\Delta\theta_1 T_0}{\alpha\Delta\theta_2 T_0}$

$\Rightarrow$ $\frac{12}{4} = \frac{40-\theta}{\theta-20}$

$\Rightarrow$ $3(\theta-20) = 40-\theta$

$\Rightarrow$ $4\theta = 100$

$\Rightarrow$ $\theta = 25°$ C

Time gained or lost is given by

$$\Delta T = \left(\frac{\Delta T}{T_0 + \Delta T}\right)t \approx \frac{\Delta t}{T_0}t$$

From Eq. (i), $\frac{\Delta T}{T_0} = \frac{\alpha\Delta\theta}{2}$

$\therefore$ $\Delta t = \frac{\alpha(\Delta\theta)t}{2}$

$$12 = \frac{\alpha(40-25)(24 \times 3600)}{2}$$

$\therefore$ $\alpha = 1.85 \times 10^{-5}/°$ C

8. *(b)* $\Delta Q = \Delta U + \Delta W$

In the process $pV^n =$ constant, molar heat capacity is given by

$$C = \frac{R}{\gamma - 1} + \frac{R}{1-n}$$

$$= C_V + \frac{R}{1-n}$$

$$C - C_V = \frac{R}{1-n}$$

$$\Rightarrow \quad 1 - n = \frac{C_p - C_V}{C - C_V}$$

$$\Rightarrow \quad n = 1 - \left(\frac{C_p - C_V}{C - C_V}\right)$$

$$= \frac{(C - C_V) - (C_p - C_V)}{C - C_V} = \frac{C - C_p}{C - C_V}$$

9. *(a)* p-V equation for path AB

$$p = -\left(\frac{p_0}{V_0}\right)V + 3p_0$$

$$\Rightarrow \quad pV = 3p_0V - \frac{p_0}{V_0}V^2$$

$$\text{or} \quad T = \frac{pV}{nR} = \frac{1}{nR}\left(3p_0V - \frac{p_0}{V_0}V^2\right)$$

For maximum temperature,

$$\frac{dT}{dV} = 0$$

$$\Rightarrow \quad 3p_0 - \frac{2p_0V}{V_0} = 0$$

$$\Rightarrow \quad V = \frac{3}{2}V_0$$

$$\text{and} \quad p = 3p_0 - \frac{p_0}{V_0} = \frac{3p_0}{2}$$

Therefore, at these values :

$$\therefore \quad T_{\text{max}} = \frac{\left(\frac{3p_0}{2}\right)\left(\frac{3V_0}{2}\right)}{nR} = \frac{9p_0V_0}{4nR}$$

10. *(d)* $v = \omega\sqrt{A^2 - x^2}$ At, $x = \frac{2A}{3}$

$$v = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2} = \frac{\sqrt{5}}{3}\omega A$$

As, velocity is trebled, hence $v' = \sqrt{5}A\omega$

This leads to new amplitude A'

$$\therefore \quad \omega\sqrt{A'^2 - \left(\frac{2A}{3}\right)^2} = \sqrt{5}A\omega$$

$$\Rightarrow \quad \omega^2\left[A'^2 - \frac{4A^2}{9}\right] = 5A^2\omega^2$$

$$\Rightarrow \quad A'^2 = 5A^2 + \frac{4}{9}A^2 = \frac{49}{9}A^2$$

$$A' = \frac{7}{3}A$$

11. *(c)* At distance x from the bottom

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\left(\frac{mgx}{L}\right)}{\left(\frac{m}{L}\right)}} = \sqrt{gx}$$

$$\therefore \quad \frac{dx}{dt} = \sqrt{x}\sqrt{g}$$

$$\Rightarrow \quad \int_0^L x^{-1/2}dx = \sqrt{g}\int_0^t dt$$

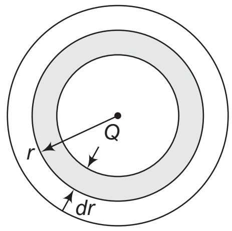
$$\Rightarrow \quad \left[\frac{x^{1/2}}{(1/2)}\Bigg|_0^L\right] = \sqrt{g}\cdot t$$

$$\Rightarrow \quad t = \frac{2\sqrt{L}}{\sqrt{g}}$$

$$\Rightarrow \quad t = 2\sqrt{\frac{20}{10}} = 2\sqrt{2}\text{ sec.}$$

12. *(a)* As E is constant,

Hence, $E_a = E_b$



As per Guass theorem, only Q_{in} contributes in electric field.

$$\therefore \quad \frac{kQ}{a^2} = \frac{k\left[Q + \int_a^b 4\pi r^2 dr \cdot \frac{A}{r}\right]}{b^2}$$

$$\text{Here,} \quad k = \frac{1}{4\pi\varepsilon_0}$$

$$\Rightarrow \quad Q\frac{b^2}{a^2} = Q + 4\pi A\left[\frac{r^2}{2}\Bigg|_a^b\right]$$

$$= Q + 4\pi A \cdot \left(\frac{b^2 - a^2}{2}\right)$$

$$\Rightarrow \quad Q\left(\frac{b^2}{a^2}\right) = Q + 2\pi A(b^2 - a^2)$$

$$\Rightarrow \quad Q\left(\frac{b^2 - a^2}{a^2}\right) = 2\pi A(b^2 - a^2)$$

$$\Rightarrow \quad A = \frac{Q}{2\pi a^2}$$

13. *(c)* $3\,\mu\text{F}$ and $9\mu\text{F} = 12\mu\text{F}$

$$4\mu\text{F and } 12\mu\text{F} = \frac{4 \times 12}{4 + 12} = 3\mu\text{F}$$

$$Q = CV = 3 \times 8 = 24\mu\text{C} \quad (\text{on } 4\mu\text{F and } 3\mu\text{F})$$

Now, this $24\mu\text{C}$ distributes in direct ratio of capacity between $3\mu\text{F}$ and $9\mu\text{F}$. Therefore,

$$Q_{9\mu\text{F}} = 18\mu\text{C}$$

$\therefore \quad Q_{4\mu F} + Q_{9\mu F} = 24 + 18 = 42\mu C = Q$ (say)

$$E = \frac{kQ}{R^2}$$

$$= \frac{9 \times 10^9 \times 42 \times 10^{-6}}{30^2}$$

$$= 420 \text{ N/C}$$

14. *(c)* As, we know Cu is conductor, so increase in temperature, resistance will increases. Then, Si is semiconductor, so with increase in temperature, resistance will decreases.

15. *(d)* B at centre of a circle $= \dfrac{\mu_0 I}{2R}$

B at centre of a square

$$= 4 \times \frac{\mu I}{4\pi \cdot \frac{l}{2}}[\sin 45^\circ + \sin 45^\circ]$$

$$= 4\sqrt{2}\, \frac{\mu_0 I}{2\pi l}$$

Now, $R = \dfrac{L}{2\pi}$ and $l = \dfrac{L}{4}$ (as $L = 2\pi R = 4l$)

where, L = length of wire.

$$\therefore \quad B_A = \frac{\mu_0 I}{2 \cdot \frac{L}{2\pi}} = \frac{\pi\mu_0 I}{L} = \pi\left[\frac{\mu_0 I}{L}\right]$$

$$B_B = 4\sqrt{2}\, \frac{\mu_0 I}{2\pi\left(\frac{L}{4}\right)} = \frac{8\sqrt{2}\mu_0 I}{\pi L} = \frac{8\sqrt{2}}{\pi}\left[\frac{\mu_0 I}{L}\right]$$

$$\therefore \quad \frac{B_A}{B_B} = \pi^2 : 8\sqrt{2}$$

16. *(d)* We need high retentivity and high coercivity for electromagnets and small area of hysteresis loop for transformers.

17. *(d)* $V^2 = V_R^2 + V_L^2$

$\Rightarrow 220^2 = 80^2 + V_L^2$

Solving we get,

$$V_L \approx 205 \text{ V}$$

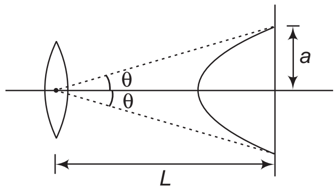
$$X_L = \frac{V_L}{I} = \frac{205}{10} = 20.5\ \Omega = \omega L$$

$$\therefore \quad L = \frac{20.5}{2\pi \times 50} = 0.065 \text{ H}$$

18. *(a)* Theoretical question. Therefore, no solution is required.

19. *(d)* Telescope resolves and brings objects closer. Hence, telescope with magnifying power of 20, the tree appears 20 times nearer.

20. *(c)*



$$a\sin\theta \approx \lambda$$

$$a\left(\frac{a}{L}\right) \approx \lambda$$

$$\Rightarrow \quad a = \sqrt{\lambda L}$$

$$\text{Spread} = 2a = \sqrt{4\lambda L}$$

21. *(a)* According to the law of conservation of energy, i.e. Energy of a photon ($h\nu$) = Work function (ϕ) + Kinetic energy of the photoelectron $\left(\frac{1}{2}mv_{\max}^2\right)$

According to Einstein's photoelectric emission of light

i.e. $E = (\text{KE})_{\max} + \phi$

As, $\dfrac{hc}{\lambda} = (\text{KE})_{\max} + \phi$

If the wavelength of radiation is changed to $\dfrac{3\lambda}{4}$, then

$$\Rightarrow \quad \frac{4}{3}\frac{hc}{\lambda} = \left(\frac{4}{3}(\text{KE})_{\max} + \frac{\phi}{3}\right) + \phi$$

$(\text{KE})_{\max.}$ for fastest emitted electron $= \dfrac{1}{2}mv'^2 + \phi$

$$\Rightarrow \quad \frac{1}{2}mv'^2 = \frac{4}{3}\left(\frac{1}{2}mv^2\right) + \frac{\phi}{3}$$

i.e. $$v' > v\left(\frac{4}{3}\right)^{1/2}$$

22. *(d)* **A :** Numbers left : N $\rightarrow \dfrac{N}{2} \rightarrow \dfrac{N}{4} \rightarrow \dfrac{N}{8} \rightarrow \dfrac{N}{16}$

$\therefore$ Number decayed, $N_A = N - \dfrac{N}{16} = \dfrac{15}{16}N$

B : Numbers left : $N \rightarrow \dfrac{N}{2} \rightarrow \dfrac{N}{4}$

$\therefore$ Numbers decayed, $N_B = N - \dfrac{N}{4} = \dfrac{3}{4}N$

Ratio : $\dfrac{N_A}{N_B} = \dfrac{(15/16)N}{(3/4)N} = \dfrac{5}{4}$

23. *(c)* Output of OR gate is 0 when all inputs are 0 and output is 1 when atleast one of the input is 1.

Observing output *x* It is 0 when all inputs are 0 and it is 1 when atleast one of the input is 1.

$\therefore$ The gate is OR.

Alternative Method

OR Gate

A	B	C	D	X
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1

24. *(a)* In amplitude modulation, $\mu = \frac{A_m}{A_c}$

25. *(b)* Least count

$$\frac{\text{pitch}}{\text{number of divisions on circular scale}} = \frac{0.5 \text{ mm}}{50}$$

$\therefore$ LC = 0.01

Negative zero error $= -5 \times \text{LC} = -0.005$ mm

Measured value = main scale reading + screw gauge reading − zero error

$= 0.5 \text{ mm} + \{25 \times 0.01 - (-0.05)\}$ mm

$= 0.8$ mm

26. *(d)* Fundamental frequency of open pipe.

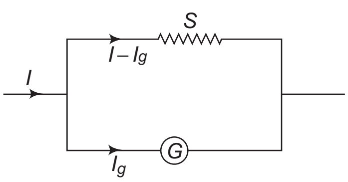
$$f = \frac{v}{2l}$$

Now, after half filled with water it becomes a closed pipe of length $\frac{l}{2}$.

Fundamental frequency of this closed pipe,

$$f' = \frac{v}{4(l/2)} = \frac{v}{2l} = f$$

27. *(a)*



In parallel, current distributes in inverse ratio of resistance. Hence,

$$\frac{I - I_g}{I_g} = \frac{G}{S}$$

$$\Rightarrow \quad S = \frac{GI_g}{I - I_g}$$

As I_g is very small, hence

$$S = \frac{GI_g}{I}$$

$$b = \frac{(100)(1 \times 10^{-3})}{10} = 0.01\ \Omega$$

28. *(a)* $\delta = (i_1 + i_2) - A$

$\Rightarrow \quad 40° = (35° + 79°) - A$

$\Rightarrow \quad A = 74°$

Now, we know that

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

It we take the given deviation as the minimum deviation then,

$$\mu = \frac{\sin\left(\frac{74° + 40°}{2}\right)}{\sin\left(\frac{74°}{2}\right)}$$

$= 1.51$

The given deviation may or may not be the minimum deviation. Rather it will be less than this value. Therefore, μ will be less than 1.51.

Hence, maximum possible value of refractive index is 1.51.

29. *(a)* Theoretical question. Therefore, no solution is required.

30. *(b, d)*

$$I_b + I_c = I_e \Rightarrow \frac{I_b}{I_c} + 1 = \frac{I_e}{I_c}$$

$$\Rightarrow \quad \frac{1}{\beta} + 1 = \frac{1}{\alpha} \Rightarrow \frac{1}{\alpha} = \frac{1 + \beta}{\beta}$$

$$\Rightarrow \quad \alpha = \frac{\beta}{1 + \beta}$$