PHYSICS

SET - 1

Category-1 (Q. 1 to 30)

(Carry 1 mark each. Only one option is correct. Negative marks : – ¼

Category-1

1. Three concentric metal shells A, B and C of respective radii, a, b and c(a < b < c) have surface charge densities +σ,–σ and +σ respectively. The potential of shell B is

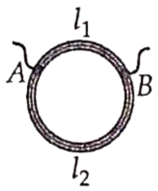
a, b ও c ব্যাসার্ধের তিনটি সমকেন্দ্রীক গোলীয় খোলকের তলমাত্রিক ঘনত্ব যথাক্রমে +σ,–σ এবং +σ । B খোলকের বিভব হল

(1) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{a}+c\right]$ (2) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{b}+c\right]$

(3) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{b}+a\right]$ (2) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{c}+a\right]$

2. A ring is made of a wire having a resistance $R_0 = 12\Omega$. Find the points A and B, as shown in the figure, at which a current carrying conductor should be connected so that the resistance R of the sub circuit between these points is equal to $\frac{8}{3}\Omega$

12Ω রোধের তার থেকে একটি রিং তৈরি হয়েছে। A ও B তে তড়িৎ প্রবাহী তার যুক্ত করলে A ও B এর তুল্য রোধ $\frac{8}{3}\Omega$ হবে কোন শর্তে ?



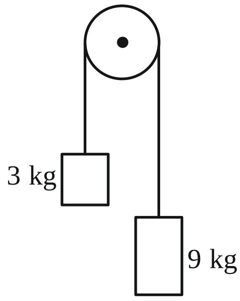
(1) $\frac{l_1}{l_2}=\frac{5}{8}$

(2) $\frac{l_1}{l_2}=\frac{1}{3}$

(3) $\frac{l_1}{l_2}=\frac{3}{8}$

(4) $\frac{l_1}{l_2}=\frac{1}{2}$

3. Two bodies of mass 3 kg and 9 kg are tied to the ends of a massless string. The string passes over a pulley which is frictionless (see figure). The acceleration of the system in terms of acceleration due to gravity (g) is



3 kg ও 9 kg ভরের দুটি ব্লক একটি ভরহীন একটি সূত্রের সাহায্যে একটি কপিকলের মাধ্যমে ঝুলছে। সংস্থাটির ত্বরণ হবে -

(1) g (2) g/2

(3) 3g/5 (4) g/10

4. A compressive force is applied to a uniform rod of rectangular cross-section so that its length decreases by 1%. If the Poisson's ratio for the material of the rod be 0.2, which of the following statements is correct? The volume approximately

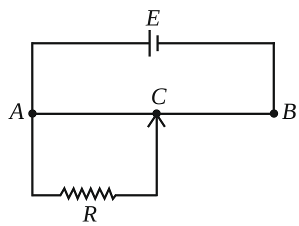
একটি আয়তাকার প্রস্থচ্ছেদ যুক্ত রডে বল প্রয়োগের দরুণ দৈর্ঘ্য 1% কমে যায়। রডের উপাদানের Poisson অনুপাত 0.2 । রডের আয়তন

(1) decreases by 1% (2) decreases by 0.6%

(3) decreases by 0.8% (4) increases by 0.2%.

5. Figure shows a potentiometer. Length of the potentiometer wire AB is 100 cm and its resistance is 100Ω. EMF of the battery E is 2 V. A resistance R of 50Ω draws current from the potentiometer. What is the voltage across R when the sliding contact C is at the mid-point of AB?

পোটেনশিওমিটার এর তারের দৈর্ঘ্য AB = 100 cm এবং রোধ 100Ω. । E = 2 V । 50Ω. রোধের রোধক R চিত্রানুযায়ী যুক্ত আছে। C বিন্দু, A ও B এর মধ্যবিন্দু। R রোধকে বিভব পতন হল



(1) 2/3 V (2) 1V

(3) 4/3 V (4) 3/2 V

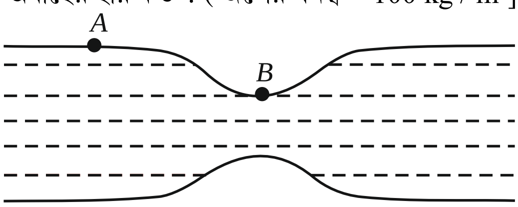
6. A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings 5.50 mm, 5.55 mm, 5.54 mm, 5.65 mm. The average of these four readings is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should therefore be recorded as

একটি পেনশিলের ব্যাস একটি ভার্নিয়ার স্কেলের সাহায্যে মাপ করলে ব্যাসের দৈর্ঘ্য পাওয়া যায় 5.50 mm, 5.55 mm, 5.54 mm, 5.65 mm । চারটি পাঠের গড় মান 5.5375 mm এবং প্রমাণ বিচ্যুতি 0.07395 mm । ব্যাসের গড় মান লেখা হবে -

(1) (5.5375 ± 0.0739) mm
(2) (5.5375 ± 0.0740) mm
(3) (5.538 ± 0.074) mm
(4) (5.54 ± 0.07) mm

7. Water flows in a horizontal tube (see figure). The pressure of water changes by 700 N m^{-2} between A and B where the area of cross section are 40 cm^2 and 20 cm^2, respectively. Find the rate of flow of water through the tube. (density of water = 1000 kg m^{-3})

চিত্রানুযায়ী অনুভূমিক নলের মধ্য দিয়ে জল প্রবাহিত হচ্ছে। A ও B বিন্দুর মধ্যে চাপের পার্থক্য 700 N m^{-2} । A ও B তে প্রস্থচ্ছেদের ক্ষেত্রফল 40 cm^2 ও 20 cm^2। জল প্রবাহের হার কত ? (জলের ঘনত্ব = 100 kg / m^3]



(1) 3020 cm^3/s (2) 2420 cm^3/s
(3) 2720 cm^3/s (4) 1810 cm^3/s

8. The bob of a simple pendulum performs SHM with period T in air and with period T_1 in water. Relation between T and T_1 is (neglect friction due to water, density of the material of the bob = $\frac{9}{8} \times 10^3$ kg/m^3, density of water 1 g/cc)

একটি সরল দোলকের দোলনকাল বায়ুতে T ও জলে T_1 (জলের বাধা অগ্রাহ্য করলে, দোলক পিণ্ডের ঘনত্ব $\frac{9}{8} \times 10^3$ kg/m^3, জলের ঘনত্ব 1 g/cc) । T ও T_1 এর মধ্যে সম্পর্ক

(1) $T_1 = 3T$ (2) $T_1 = 2T$
(3) $T_1 = T$ (4) $T_1 = \frac{T}{2}$

9. A uniform thin rod AB of length L has linear mass density $\mu(x) = a + \frac{bx}{L}$, where x is measured from A. If the CM of the rod lies at a distance of $\left(\frac{7}{12}L\right)$ from A, then a and b are related as of

L দৈর্ঘ্যের একটি রডের রৈখিক ভর ঘনত্ব $\mu(x) = a + \frac{bx}{L}$ যেখানে x মাপা হয় A থেকে। রডের ভরকেন্দ্র A থেকে $\left(\frac{7}{12}L\right)$ দূরে। a ও b এর মধ্যে সম্পর্ক হল -

(1) a = b (2) a = 2b
(3) 2a = b (4) 3a = 2b

10. The half life of a radioactive substance is 20 minutes. The time taken between 50% decay and 87.5% decay of the substance will be

একটি তেজস্ক্রিয় নমুনার অর্ধজীবনকাল 20 মিনিট। 50% বিঘটন ও 87.5% বিঘটনের মধ্যবর্তী সময় হল

(1) 20 minutes (2) 30 minutes
(3) 40 minutes (4) 25 minutes

11. A uniform thin rod of length L, mass M is lying on a smooth horizontal table. A horizontal impulse P is suddenly applied perpendicular to the rod at one end. The total energy of the rod after the impulse is

একটি L দৈর্ঘ্যের ও M ভরের পাতলা রড একটি মসৃণ অনুভূমিক টেবিলে রয়েছে। রডের এক প্রান্তে হঠাৎ একটি ঘাত P লম্বভাবে প্রয়োগ করলে রডের মোট শক্তি হবে

(1) $\frac{p^2}{M}$ (2) $\frac{7P^2}{8M}$
(3) $\frac{13P^2}{2M}$ (4) $\frac{2P^2}{M}$

12. An early model for an atom considered it to have a positively charged point nucleus of charge Ze, surrounded by a uniform density of negative charge upto a radius R. The atom as a whole is neutral. The electric field at a distance r from the nucleus is (r < R)

প্রথমের দিকে পরমাণু মডেল এভাবে ছিল যে Ze আধানের বিন্দু নিউক্লিয়াস অবস্থিত ছিল, ব্যাসার্ধ R পর্যন্ত সুষম ঋণাত্মক আধানের মাঝে। সম্পূর্ণ পরমাণু প্রশমিত। নিউক্লিয়াস থেকে r দূরত্বে তড়িৎক্ষেত্রের মান হবে (r < R)

(1) $\frac{Ze}{4\pi\varepsilon_0}\left[\frac{1}{r^2} - \frac{r}{R^3}\right]$ (2) $\frac{Ze}{4\pi\varepsilon_0}\left[\frac{1}{r^3} - \frac{r}{R^2}\right]$

(3) $\frac{Ze}{4\pi\varepsilon_0}\left[\frac{r}{R^3} - \frac{1}{r^2}\right]$ (4) $\frac{Ze}{4\pi\varepsilon_0}\left[\frac{r}{R^3} + \frac{1}{r^2}\right]$

13. Water droplets are coming from an open tap at a particular rate. The spacing between a droplet observed at 4th second after its fall to the next droplet is 34.3 m. At what rate the droplets are coming from the tap? (Taking g = 9.8 m/s²)

একটি খোলা নল থেকে জলের ফোঁটা একটি নির্দিষ্ট হারে পড়ছে। একটি ফোঁটা পড়ার 4 সেকেন্ড পরে পরবর্তী ফোঁটা পড়ার সময় ফোঁটা দুটির দূরত্ব 34.3 m । নল থেকে ফোঁটা বেরিয়ে আসার হার হল

(1) 1 drop/7 seconds (2) 1 drop/second
(3) 3 drops/2 second (4) 2 drops/second

14. A human body has a surface area of approximately 1 m². The normal body temperature is 10 K above the surrounding room temperature T_0. Take the room temperature to be To = 300 K. For To = 300 K, the value of $\sigma T_0^4 = 460 W\, m^{-2}$ (where σ is the Stefan Boltzmann constant). Which of the following options is correct?

একটি মানবদেহের ক্ষেত্রফল প্রায় 1 m²। দেহের স্বাভাবিক উষ্ণতা room temperature 300 K অপেক্ষা 10K বেশী। 300 K এর ক্ষেত্রে $\sigma T_0^4 = 460 W\, m^{-2}$ । নিচের কোনটি সঠিক ?

(1) If the body temperature rises significantly then the peak in the spectrum of electromagnetic radiation emitted by the body would shift to longer wavelengths.
(2) If the surrounding temperature reduces by a small amount $\Delta T << T_0$, then to maintain the same body temperature the same (living) human being needs to radiate $4T_0^3 \Delta T_0$ more energy per unit time.
(3) The amount of energy radiated by the body in 1 second is close to 60 Joules.
(4) Reducing the exposed surface area of the body (e.g. by curling up) allows humans to maintain the same body temperature while reducing the energy lost by radiation.

15. The closed and open pipes have same length. When they are vibrating simultaneously in first overtone, produce three beats. The length of open pipe is made $\frac{1}{3}^{rd}$ and closed pipe is made three times the original, the number of beats produced will be

একই দৈর্ঘ্যের একটি খোলা ও বদ্ধ পাইপ রয়েছে। উভয়ে একসাথে প্রথম উপসুরে কম্পনরত। তিনটি স্বরকম্প সৃষ্টি হয়। খোলা নলকে $\frac{1}{3}^{rd}$ অংশ এবং বদ্ধ নলকে 3 গুণ করা হল। এখন কতগুলি স্বরকম্প সৃষ্টি হবে ?

(1) 8 (2) 14
(3) 17 (4) 20

16. A block of mass 1.0 kg moving on a horizontal surface with speed 2 m/s enters a rough surface. The retarding force (F_r) on the block is given by

$$F_r = \begin{cases} -\frac{k}{x} & ; 10m < x < 100m \end{cases}$$

where k = 0.5 J. The kinetic energy of the block at x = 100 m is

1.0 kg ভরের একটি ব্লক 2 m/s বেগে একটি অমসৃণ তলে প্রবেশ করলো। বাধা বল

$$F_r = \begin{cases} -\frac{k}{x} & ; 10m < x < 100m \end{cases}$$

সেখানে k = 0.5 J। x = 100 m এ ব্লকের গতিশক্তি হবে

(1) 4.5 J (2) 2.5 J
(3) 0.85 J (4) 1.5 J

17. When heat energy of 1500 J is supplied to a gas at constant pressure, 2.1×10^5 N m⁻², there was an increase in its volume equal to 2.5×10^{-3} m³. The increase in its internal energy is

2.1×10^5 N m⁻², স্থির চাপে একটি গ্যাসকে 1500 J দিলে গ্যাসের আয়তন বৃদ্ধি হয় 2.5×10^{-3} m³। অভ্যন্তরীণ শক্তির বৃদ্ধি হবে

(1) 450 J (2) 525 J
(3) 975 J (4) 2025 J

18. When a 60 mH inductor and a resistor are connected in series with an AC voltage source, the voltage leads the current by 60°. If the inductor is replaced by a 0.5 μF capacitor, the voltage lags behind the current by 30°. What is the frequency of the AC supply?

60 mH আবেশক ও একটি রোধ একটি AC উৎসের সাথে যুক্ত থাকলে, ভোল্টেজ 60° দশা কোণে এগিয়ে থাকে। আবেশক এর পরিবর্তে 0.5 μF ধারক যুক্ত করলে ভোল্টেজ 30° দশা কোণে পিছিয়ে থাকে। AC উৎসের কম্পাঙ্ক কত ?

(1) $\frac{1}{2\pi} \times 10^4 Hz$
(2) $\frac{1}{\pi} \times 10^4 Hz$
(3) $\frac{3}{2\pi} \times 10^4 Hz$
(4) $\frac{1}{2\pi} \times 10^8 Hz$

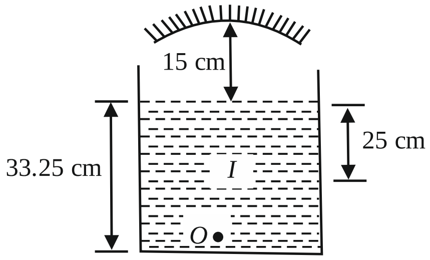
19. The number of significant figures in $(3.20 + 4.80) \times 10^5$ is

$(3.20 + 4.80) \times 10^5$ এ তাৎপর্যপূর্ণ অঙ্ক সংখ্যা হল

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

20. A container is filled with water (μ = 1.33) upto a height of 33.25 cm. A concave mirror is held 15 cm above the water level, and the image I of an object O placed at the bottom is formed 25 cm below the water level. The focal length of the mirror is roughly

33.25 উচ্চতা, 1.33 প্রতিসরাঙ্কের জলপূর্ণ একটি পাত্রের 15 cm উঁচুতে একটি অবতল দর্পণ রয়েছে। পাত্রের তলদেশে থাকা বস্তুর প্রতিবিম্ব জলতল থেকে 25 cm নিচে। দর্পণের ফোকাস দূরত্ব প্রায়



(1) 10 cm (2) 15 cm
(3) 20 cm (4) 25 cm

21. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energy is

বৃত্তাকার পথে ঘূর্ণায়মান একটি কণা $U = -\frac{k}{2r^2}$ বিভবে রয়েছে। কণাটির মোট শক্তি হল

(1) $-\frac{k}{4a^2}$ (2) $\frac{k}{2a^2}$
(3) Zero (4) $-\frac{3}{2}\frac{k}{a^2}$

22. In Young's double slit experiment, using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ is *K* units. The intensity of light at a point where path difference is λ/3 is

Young's double slit experiment এ ব্যবহৃত একবর্ণী আলোর তরঙ্গদৈর্ঘ্য λ পর্দার যে অবস্থানে পথপার্থক্য λ, সেখানে আলোর তীব্রতা *K* । যেখানে পথপার্থক্য λ/3 সেখানে আলোর তীব্রতা -

(1) 4K (2) K
(3) 2K (4) K/4

23. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is

m ভরের একটি দড়ি দিয়ে M ভরের একটি ব্লককে একটি সমৃণ তলে P বলে টানলে, দড়ি দ্বারা ব্লকের ওপর প্রযুক্ত বল

(1) $\frac{Pm}{(M+m)}$ (2) $\frac{Pm}{(M-m)}$
(3) P (4) $\frac{Pm}{(M+m)}$

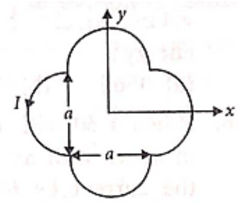
24. The stopping potential for a metallic surface illuminated by monochromatic light of wavelength λ is $4V_0$ while for another light of wavelength 3λ it is V_0. The threshold wavelength of the surface for photoelectric emission is

λ তরঙ্গদৈর্ঘ্যের একবর্ণী আলো একটি ধাতব তলে পড়লে নিবৃত্তি বিভব হয় $4V_0$। 3λ তরঙ্গদৈর্ঘ্যের আলো ব্যবহার করলে নিবৃত্তি বিভব হয় V_0। তলটির প্রারম্ভ λ তরঙ্গদৈর্ঘ্য হল

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

25. A loop carrying current I lies in the x-y plane as shown in the figure. The unit vector $\hat{k}$ is coming out of the plane of the paper. The magnetic moment of the current loop is

চিত্রানুযায়ী লুপে I তড়িৎপ্রবাহ রয়েছে। লুপটির চৌম্বক ভ্রামক হল



(1) $a^2 I\hat{k}$
(2) $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$
(3) $-\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$
(4) $(2\pi+1)a^2 I\hat{k}$

26. An object is dropped from a height h from the ground. Every time it hits the ground it looses 50% of its kinetic energy. The total distance covered at t→ ∞ is

ভূমি থেকে h উচ্চতা থেকে একটি বস্তুকে ছাড়লে ভূমি আঘাত করার সময় ইহা প্রতিবার 50% শক্তি হারায়। এটি মোট কত দূরত্ব অতিক্রম করবে যখন t→ ∞

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

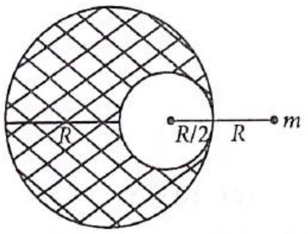
27. In a p-n-p transistor, 10^{10} holes enter the emitter in 10 s. If 2% of holes is lost in the base, then the current amplification factor is

একটি p-n-p ট্রানজিস্টারে, 10^{10} হোল 10 সেকেন্ডে নিঃসারকে প্রবেশ করে। ভূমিতে 2% হোল নষ্ট হলে প্রবাহ বিবর্ধক গুণক হবে -

(1) 49 (2) 19
(3) 29 (4) 39

28. An uniform solid sphere of radius R exerts gravitational force F on a particle placed at 2R from the center of the sphere. A spherical cavity of radius R/2 is made (as shown). The sphere (with cavity) now applies a force F' on the same particle. The ratio F'/F is

একটি সুষম নিরেট R ব্যাসার্ধের গোলক তার ভর কেন্দ্র থেকে 2R দূরে অবস্থিত একটি কণার ওপর F বল প্রয়োগ করে। চিত্রানুযায়ী এখন R/2 ব্যাসার্ধের গর্ত তৈরি করলে F' বল প্রয়োগ করে। F'/F হল



(1) $\frac{7}{9}$

(2) $\frac{7}{8}$

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

(4) $\frac{3}{4}$

29. A circular coil of radius 10 cm, 500 turns of wire of total resistance 2Ω is placed with its plane perpendicular to the horizontal component of the Earth's magnetic field. It is rotated about its vertical diameter by 180° in 0.25 seconds. Estimate the induced e.m.f. in the coil. (Given the horizontal component of Earth's field = 3×10^{-5} T)

500 পাকের, 10 cm ব্যাসার্ধের 20Ω রোধের একটি বৃত্তাকার কুন্ডলীর তল ভূচৌম্বক ক্ষেত্রের অনুভূমিক উপাংশের সাথে লম্বভাবে আছে। কুন্ডলীর উল্লম্ব ব্যাস সাপেক্ষে 0.25 সেকেন্ডে 180°ঘোরালে আবিষ্ট তড়িৎচালক বলের মান প্রায় ($B_H = 3\times10^{-5}$ T)

(1) 4×10^{-3}V (2) 6×10^{-3} V
(3) 8×10^{-3} V (4) 10×10^{-3}V

30. A current of 1 A is flowing on the sides of an equilateral triangle of side 4.5×10^{-2} m. The magnetic field at the centre of the triangle will be
একটি সমবাহু ত্রিভুজের বাহুর মধ্যে 1 A তড়িৎপ্রবাহ রয়েছে। বাহুর দৈর্ঘ্য 4.5×10^{-2} m। ত্রিভুজের কেন্দ্রে চৌম্বকক্ষেত্রের মান -

(1) 4×10^{-5} Wb/m²
(3) 2×10^{-5} Wb/m²
(2) 8×10^{-5} Wb/m²
(4) Zero

Category-2 (Q. 1 to 5)

(Carry 2 mark each. Only one option is correct.
Negative marks : – 1⁄2

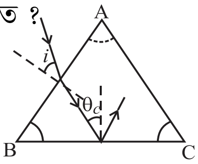
1. If g = acceleration due to gravity and R = radius of the earth, then $\left(\frac{g}{R}\right)^{1/2}$ represents the dimension of

$\left(\frac{g}{R}\right)^{1/2}$ এর মাত্রা নিচের কোনটির মাত্রার সমান হবে ?
R = পৃথিবীর ব্যাসার্ধ

(1) angular speed (2) escape speed
(3) orbital speed (4) acceleration

2. A light is incident on face AB of an equilateral glass prism ABC. After refraction at AB, the ray is incident on face BC at the angle slightly greater than critical angle so that it gets reflected from face BC and finally emerges out from face AC. Net deviation angle of the ray is 112° anticlockwise. The angle of incidence 'i' has value:

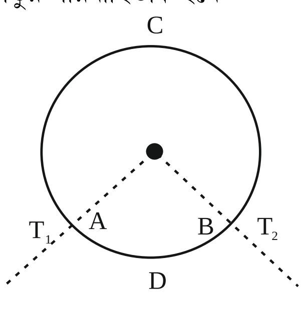
একটি সমবাহু প্রিজম ABC এর AB তলে আলো আপতিত হয়ে প্রতিসরণের পর BC তলে প্রতিফলিত হয়ে AC তল দিয়ে নির্গত হয়। মোট চ্যুতি 112°। i এর মান কত ?



(1) 22° (2) 24°
(3) 26° (4) 28°

3. A ring consisting of two parts ADB and ACB of same conductivity K carries an amount of heat H. the ADB part is now replaced with another metal keeping the tempertures T_1 and T_2 constant. The heat carried increases to $2H$. What should be the conductivity of the new ADB part? $\left(\text{Take, } \frac{ACB}{ADB} = 3\right)$

একটি রিং এর সমান পরিবাহিতাঙ্ক (K) বিশিষ্ট দুটি অংশ ADB ও ACB তাপ পরিবহণ করে। T_1 ও T_2 (উষ্ণতা স্থির রেখে ADB অংশে অন্য ধাতু প্রতিস্থাপন করলে তাপ পরিবহণ $2H$ হয়। নতুন ধাতুর পরিবাহিতাঙ্ক হবে



(1) $\frac{7}{3}K$ (2) 2K

(3) $\frac{5}{2}K$ (4) $3K$

4. The equation of motion of a projectile are given by $x = 36t$ metre and $2y = 96t - 9.8t^2$ metre. The angle of projection is

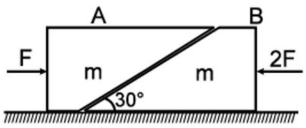
একটি প্রাসের সমীকরণ হল $x = 36t$ ও $2y = 96t - 9.8t^2$ । প্রক্ষেপ কোণ কত ?

(1) $\sin^{-1}\left(\frac{4}{5}\right)$ (2) $\sin^{-1}\left(\frac{3}{5}\right)$

(3) $\sin^{-1}\left(\frac{4}{3}\right)$ (4) $\sin^{-1}\left(\frac{3}{4}\right)$

5. Two blocks 'A' and 'B' each of mass 'm' are placed on a smooth horizontal surface. Two horizontal force F and $2F$ are applied on the two blocks 'A' and 'B' respectively as shown in figure. The block A does nto slide on block B. Then the normal reaction acting between the two blocks is: (A and B are smooth)

m ভরের দুটি ব্লক A ও B কে একটি মসৃণ তলে রেখে A ও B এর ওপর যথাক্রমে F ও $2F$ বল প্রয়োগ করা হল। A ব্লক, B ব্লকের ওপর পিছলে যায়নি। ব্লক দুটির মধ্যে লম্ব প্রতিক্রিয়া বল হল



(1) F (2) $F/2$

(3) $\frac{F}{\sqrt{3}}$ (4) $3F$

Category-3 (Q. 1 to 5)

(Carry 2 mark each. One or more option are correct. No negative marks.

1. A negative point charge is brought in an uniform electric field. The electric field at a nearby point

একটি ঋণাত্মক বিন্দু আধানকে একটি সুষম তড়িৎক্ষেত্রে নিয়ে এলে, নিকট কোনো বিন্দুতে তড়িৎক্ষেত্র

(1) may increase (2) may decrease

(3) both (1) and (2) (4) remain unchanged

2. Take the effect of bulging of earth and its rotation in account. Consider the following statements:

পৃথিবীর স্ফিত হওয়া ও ঘূর্ণনের প্রভাব ধরে,

(A) There are points outside the earth where the value of g is equal to its value at the equator.

পৃথিবীর বাইরে কোনো বিন্দুতে g এর মান, নিরক্ষীয় অঞ্চলের সমান।

(B) There are points outside the earth where the value of g is equal to its value at the poles.

পৃথিবীর বাইরে কোনো বিন্দুতে g এর মান, মেরু অঞ্চলের সমান।

(1) Both A and B are correct
(2) A is correct but B is wrong
(3) B is correct but A is wrong
(4) Both A and B are wrong.

3. An AC source rated 100 V (rms) supplies a current of 10 A (rms) to a circuit. The average power delivered by the source

একটি 100 V রেটিং এর AC উৎস একটি বর্তনীতে 10 A প্রবাহ পাঠায়। উৎস দ্বারা গড় ক্ষমতা প্রদান

(1) must be 1000 W
(2) may be 1000 W
(3) may be greater than 1000 W
(4) may be less than 1000 W

4. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is $\frac{1}{2}kx^2$ the possible cases are

একটি হালকা স্প্রিং এর এক প্রান্ত দেওয়ালে আটকানো আছে। অন্য প্রান্ত একটি ব্লকের যুক্ত যেটি মসৃণ অনুভূমিক তলে রয়েছে। কিছু সরণে, স্প্রিং দ্বারা কৃতকার্য হল $\frac{1}{2}kx^2$ সম্ভাব্য ঘটনাগুলি হল

(1) at spring was initially compressed by a distance x and finally was in its natural length
(2) it was initially stretched by a distance x and finally was in its natural length
(3) it was initially in its natural length and finally in a compressed position
(4) it was initially in its natural length and finally in a stretched position.

5. Two resistors having equal resistances are joined in series and a current is passed through the combination. Neglect any variation in resistance as the temperature changes. In a given time interval.

দুটি সমান মানের রোধকে শ্রেণীতে যুক্ত করে সমবায়ের মধ্য দিয়ে কারেন্ট পাঠানো হল। উষ্ণতা বৃদ্ধির জন্য রোধের পরিবর্তন উপেক্ষণীয়। একটি নির্দিষ্ট সময় অবকাশে-

(1) equal amounts of thermal energy must be produced in the resistors
(2) unequal amounts of thermal energy may be produced
(3) the temperature must rise equally in the resistors.
(4) the temperature may rise equally in the resistors.

ANSWER KEY

Category -1

1. **(2)**

2. **(4)**

3. **(2)**

4. **(3)**

5. **(1)**

6. **(4)**

7 **(3)**

8. **(1)**

9. **(3)**

10. **(3)**

11. **(4)**

12. **(1)**

13. **(2)**

14. **(4)**

15. **(3)**

16. **(3)**

17. **(3)**

18. **(1)**

19. **(3)**

20. **(3)**

21. **(3)**

22. **(4)**

23. **(4)**

24. **(4)**

25. **(2)**

26. **(3)**

27. **(1)**

28. **(1)**

29. **(1)**

30. **(1)**

30. **(1)**

Category -2

1. **(2)**

2. **(4)**

3. **(2)**

4. **(1)**

5. **(2)**

Category -3

1. **(4)**

2. **(1, 2, 3, 4)**

3. **(12)**

4. **(1), (2)**

5. **(3), (4)**

Hints & Solution

Category -1

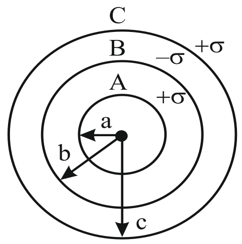
1. (2)

The potential of the shell B,

$$V_B = \frac{kq_A}{r_b} + \frac{kq_B}{r_b} + \frac{kq_C}{r_c}$$

$$= \frac{4\pi}{4\pi\varepsilon_0}\left[\frac{\sigma \times a^2}{b} - \frac{\sigma \times b^2}{b} + \frac{\sigma \times c^2}{c}\right]$$

$$= \frac{\sigma}{\varepsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$$



2. (4)

Let x be resistance per unit length of the wire.
Then, Resistance of the upper portion is $R_1 = xl_1$
Resistance of the lower portion is $R_2 = xl_2$
Equivalent resistance between A and B is

$$R = \frac{R_1R_2}{R_1 + R_2} = \frac{(xl_1)(xl_2)}{xl_1 + xl_2}$$

$$\frac{8}{3} = \frac{xl_1l_2}{l_1 + l_2} \text{ or } \frac{8}{3} = \frac{xl_1l_2}{l_2\left(\frac{l_1}{l_2} + 1\right)}$$

Or $\frac{8}{3} = \frac{xl_1}{\left(\frac{l_1}{l_2} + 1\right)}$

Also $R_0 = xl_1 + xl_2$; $12 = x(l_1 + l_2)$

$12 = xl_2\left(\frac{l_1}{l_2} + 1\right)$, Divide (i) by (ii), we get

$$\frac{\frac{8}{3}}{12} = \frac{\frac{xl_1}{\left(\frac{l_1}{l_2} + 1\right)}}{xl_2\left(\frac{l_1}{l_2} + 1\right)} \text{ or } \frac{8}{36} = \frac{l_1}{l_2\left(\frac{l_1}{l_2} + 1\right)^2}$$

$$\left(\frac{l_1}{l_2} + 1\right)^2 \frac{8}{36} = \frac{l_1}{l_2} \text{ or } \left(\frac{l_1}{l_2} + 1\right)^2 \frac{2}{9} = \frac{l_1}{l_2}$$

Let $y = \frac{l_1}{l_2}$

$\therefore 2(y+1)^2 = 9y$ or $2y^2 + 2 + 4y = 9y$

Or $2y^2 - 5y + 2 = 0$

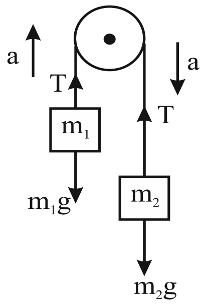
Solving this quadratic equation, we get

$y = \frac{1}{2}$ or $2 \therefore \frac{l_1}{l_2} = \frac{1}{2}$

3. (2)

Given : $m_1 = 3$ kg, $m_2 = 9$ kg
From the diagram,
$T - m_1g = m_1a$ …(i)
$m_2 g - T = m_2a$ …..(ii)
Solving equation (i) and (ii)

$$a = \frac{(m_2 - m_1)g}{m_2 + m_1} = \frac{(9-3)g}{12} = \frac{6}{12}g = \frac{g}{2}$$



4. (3)

Volume of a uniform rectangular rod,

$$V = abl = Al$$

Where a = thickness, b = breadth of rod, l = length of rod and A = area of cross section

Now, as the rod is uniform, thus Poisson's ratio

$$-\frac{\Delta a / a}{\Delta l / l} = \frac{\Delta b / b}{\Delta l / l} \Rightarrow \frac{\Delta a}{a} = \frac{\Delta b}{b}$$

Now, volume of rectangular rod, $V = abl$

$$\Rightarrow \frac{\Delta V}{V} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta l}{l}$$

$$\Rightarrow \frac{\Delta a}{a} + \frac{\Delta a}{a} + \frac{\Delta l}{l} = 2\frac{\Delta a}{a} + \frac{\Delta l}{l} \quad \text{……(i)}$$

Again, Poisson's ratio

$$(\sigma) = -\frac{\Delta a / a}{\Delta l / l} \Rightarrow \frac{\Delta a}{a} = -\sigma\frac{\Delta l}{l}$$

Putting the value of $\frac{\Delta a}{a}$ in eq. (i), we get

$$\frac{\Delta V}{V} = -2\sigma\frac{\Delta l}{l} + \frac{\Delta l}{l} = \frac{\Delta l}{l}(1 - 2\sigma)$$

$= 1 \times [1 - (2 \times 0.2)] = 1 \times (1 - 0.4) = 0.6$

Now, as per the question, length was decreasing by 1%, so considering $\frac{\Delta l}{l}$ - negative, then $\frac{\Delta V}{V}$ will also become negative.

This signifies that volume approximately decreases by 0.6%

5. **(1)**
When the sliding contact is in the middle of the potentiometer for wire AB, only half of the resistance of the potentiometer wire (= 50 Ω) will be between the points A and C.
Total resistance between A and C is

$$\frac{1}{R'} = \frac{1}{50} + \frac{1}{50} \Rightarrow \frac{1}{R'} = \frac{1}{25}$$

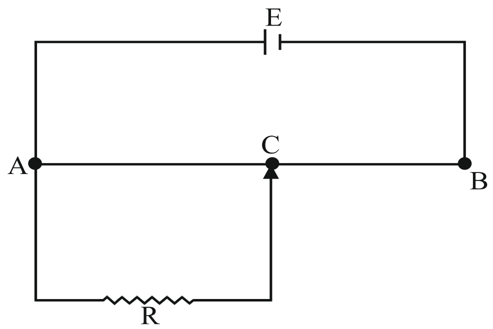
$$\Rightarrow R' = 25\Omega$$

And the total resistance between A and B is
R" = R' + 50 = 25 + 50 = 75 Ω
∴ The current flowing through the potentiometer wire is

$$I = \frac{V}{R''} = \frac{2}{75} A$$

The potential across R is

$$V' = IR' = \frac{2}{75} \times 25 = \frac{2}{3} V$$



6. **(4)**
Here dav = 5.5375 mm ≈ 5.54 mm
Δd = 0.07395 mm ≃ 0.07 mm
Average diameter of the pencil = (5.54 ± 0.07) mm

7. **(3)**
$A_A = 40\ cm^2$, AB = 20 cm^2, $\rho = 1000\ kg/m^3$
$P_A - P_B = 700$
According to equation of continuity, $A_A.V_A = A_B.V_B$
$40V_A = 20\ V_B \Rightarrow V_B = 2V_A$
Using Bernoulli's theorem

$$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2 \text{ or } P_A - P_B = \frac{1}{2}\rho\left(V_B^2 - V_A^2\right)$$

$$700 = \frac{1}{2} \times 1000\left(4V_A^2 - V_A^2\right) \text{ or } V_A^2 = \frac{7}{5 \times 3}$$

$V_A = 0.68$ m/s = 68 cm/s
Rate of flow = $A_A.\ V_A = 40 \times 68 = 2720\ cm^3/s$

8. **(1)**
Let V be the volume of the bob, then its weight in air is $Wa = V\rho_b g$

When immersed in water, buoyancy force, $F_b = V\rho_w g$

∴ Effective weight in water, $W = W_a - F_b$

$$= V\rho_b g - V\rho_w g = V\rho_b g - V\frac{8}{9}\rho_b g = \frac{1}{9}V\rho_b g$$

∴ Effective acceleration will be $g' = \frac{g}{9}$

Now, $T = 2\pi\sqrt{\frac{l}{g}}$ and $T_1 = 2\pi\sqrt{\frac{l}{g'}}$

$$\Rightarrow \frac{T}{T_1} = \sqrt{\frac{g'}{g}} = \sqrt{\frac{1}{9}} = \frac{1}{3} \text{ or } T_1 = 3T$$

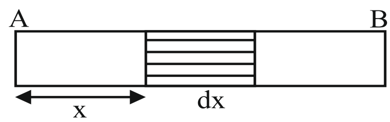
9. **(3)**
Consider a small segment dx of the rod at a distance x from A.
Mass of this small segment,

$$dm = \mu\ dx = \left(a + \frac{bx}{L}\right)dx$$

Then CM of the rod AB is given by

$$x_{CM} = \frac{\int_0^L (\mu dx)x}{\int_0^L \mu dx}; \frac{7}{12}L = \frac{\int_0^L \left(ax + \frac{bx^2}{L}\right)dx}{\int_0^L \left(a + \frac{bx}{L}\right)dx} = \frac{\left(\frac{aL^2}{2} + \frac{bL^2}{3}\right)}{\left(aL + \frac{bL}{2}\right)}$$

$$\frac{7}{12} = \frac{\frac{a}{2} + \frac{b}{3}}{a + \frac{b}{2}} \therefore b = 2a$$



10. (3)

Let in time t_1, 50% of the substance decay and in time t_2, 87.5% of the substance decay.

Then in time t_1, 50% of the substance left undecayed and in time t_2, 12.5% of the substance left undecayed.

According to radioactive decay law,

$N = N_0 e^{-\lambda t}$, where λ is the decay constant.

$$\frac{500}{100} = e^{-\lambda t_1} \text{ or } \frac{1}{2} = e^{-\lambda t_1}; \frac{12.5}{100} = e^{-\lambda t_2} \text{ or } \frac{1}{8} = e^{-\lambda t_2}$$

$$\frac{\frac{1}{8}}{\frac{1}{2}} = \frac{e^{-\lambda t_2}}{e^{-\lambda t_1}} \text{ or } \frac{1}{4} = e^{-\lambda(t_2 - t_1)}$$

$$t_2 - t_1 = \frac{\ln 4}{\lambda} = \frac{2\ln 2}{\left(\frac{\ln 2}{T_{1/2}}\right)} = 2T_{1/2}$$

$\therefore$ $t_2 - t_1 = 2$ (20 minutes) = 40 minutes

11. (4)

Mass of rod = M, Length of rod = L, Impulse = P

We know that, impulse, $P = Mv_{cm}$ …(i)

Angular momentum $= I_{cm}\omega = P.\frac{L}{2}$ …..(ii)

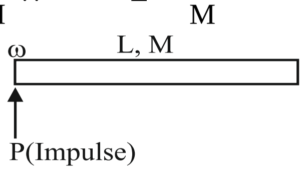
Moment of inertia, $I_{cm} = \frac{1}{12}.ML^2$

Total energy, $E = \frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$

$E = \frac{1}{2}M.\frac{P^2}{M^2} + \frac{1}{2}I_{cm} \times \frac{P^2L^2}{4I_{cm}^2}$ (Using (i) and (ii)

Or $E = \frac{P^2}{2M} + \frac{1}{2} \times \frac{P^2L^2 \times 12}{4 \times ML^2}$

Or $E = \frac{P^2}{2M} + \frac{3P^2}{2M}$ $\therefore$ $E = \frac{2P^2}{M}$



12. (1)

Charge on nucleus = Ze

Total negative charge = Ze

($\because$ atom is electrically neutral)

Negative charge density, $\rho = \frac{\text{charge}}{\text{volume}} = \frac{-Ze}{\frac{4}{3}\pi R^3}$

i.e., $\rho = -\frac{3}{4}\frac{Ze}{\pi R^3}$ ...(i)

Consider a Gaussian surface with radius r.

By Gauss's theorem,

E® $\times 4\pi r^2 = \frac{q}{\varepsilon_0}$ ….(ii)

Charge enclosed by Gaussian surface,

$q = Ze + \frac{4\pi r^3}{3}\rho = Ze - Ze\frac{r^3}{R^3}$ (Using (i))

From (ii),

$$E(r) = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{Ze - Ze\frac{r^3}{R^3}}{4\pi\varepsilon_0 r^2} = \frac{Ze}{4\pi\varepsilon_0}\left[\frac{1}{r^2} - \frac{r}{R^3}\right]$$

13. (2)

Space between a droplet at 4[th] sec after its fall to the next droplet is 34.3 m.

Distance travelled by 1[st] drop in 4 sec

$s = ut + \frac{1}{2}gt^2 = 0 + \frac{1}{2} \times 9.8 \times 4 \times 4 = 78.4\text{m}$

Distance travelled by 2[nd] drop

s' = 78.4 – 34.3 = 44.1 m

So, time taken by second drop to cover a distance of 44.1 m will be,

$44.1 = \frac{1}{2}gt'^2 \Rightarrow t' = 3\text{sec}$

So, each drop have time gap of 1 sec.

Thus, the rate is 1 drop/sec.

14. (4)

From Wein's law $\lambda_m T = b$ or $\lambda_m = \frac{b}{T}$

If the body temperature rises then the peak in the spectrum of electromagnetic radiation emitted by the body would shit to shorter wavelength. So option (a) is incorrect.

The amount of energy radiated by the body in one second is given as

Net energy emission by the body

$W_{rad} = \sigma A\left(T^4 - T_0^4\right)$

Where T is the temperature of the surrounding.

$\Delta W = \sigma A\left(0 - 4T_0^3 \Delta T_0\right); \Delta W = -4\sigma T_0^3 \Delta T_0$

The amount of energy radiated by a human body depends on its temperature. So option (b) is incorrect.

$$W = \sigma A\left(T_0 + 10\right)^4 = \sigma A T_0^4\left(1 + \frac{10}{T_0}\right)^4$$

$$= 1 \times 460\left(1 + \frac{10}{300}\right)^4 \approx 524J$$

So, option (c) is incorrect.

15. (3)

For open organ pipe, first overtone $\upsilon_1 = \frac{v}{L}$

For closed organ pipe, first overtone $\upsilon_1' = \frac{3v}{4L}$

Given : Beats = 3

$$\upsilon_1 - \upsilon_1' = 3 = \frac{v}{L} - \frac{3v}{4L} = 3 = \frac{v}{4L} = 3 \Rightarrow \frac{v}{L} = 12$$

For open organ pipe, fundamental frequency $\upsilon = \frac{v}{2L'}$

Given $L' = \frac{L}{3}$ $\therefore \upsilon = \frac{v}{2\left(\frac{L}{3}\right)} = \frac{3v}{2L}$

For closed organ pipe, fundamental frequency $\upsilon' = \frac{v}{4L'}$

Given L' = 3L

$$\therefore \upsilon' = \frac{v}{4(3L)} = \frac{\upsilon}{12L}$$

$\therefore$ Beat produced $\upsilon - \upsilon'$

$$= \frac{3v}{2L} - \frac{v}{12L} = \frac{17v}{12L} = \frac{17}{12}.12 = 17$$

16. (3)

Here, m = 1.0 kg, $v_i = 2$ m/s

Initial kinetic energy of the block is

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(1.0\ \text{kg})(2\,\text{m/s})^2 = 2\ \text{J}$$

Work done by the retarding force is

$$W = \int_{10m}^{100m} F_r dx = \int_{10}^{100}\left(-\frac{k}{x}\right)dx = -k\ln[x]_{10m}^{100m}$$

$$= -(0.5J)\ln\left[\frac{100m}{10m}\right] = -(0.5J)(2.302) = -1.15J$$

According to work-energy theorem

$K_f - K_i = W$

$\therefore K_f = K_i + W = 2J - 1.15\ J = 0.85\ J$

17. (3)

Heat supplied to the gas, $\Delta Q = 1500$ J

Work done by the gas,

$$\Delta W = P\Delta W = \left(2.1\times10^5\,\text{Nm}^{-2}\right)\left(2.5\times10^{-3}\,\text{m}^3\right)$$

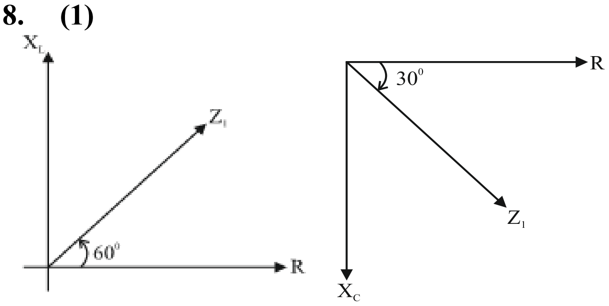
$$= 5.25\times10^2\,\text{Nm} = 525\text{J}$$

According to first law of thermodynamics,

$\Delta Q = \Delta W + \Delta U$

$\therefore \Delta U = \Delta Q - \Delta W = 1500\ \text{J} - 525\text{J} = 975\ \text{J}$

18. (1)



Now, $\tan 60^0 = \frac{X_L}{R} = \frac{\omega L}{R}$

Again, $\tan 30^0 = \frac{X_C}{R} = \frac{1}{\omega CR}$

Now, from eqn. (i) and (ii), we get

$$\frac{\tan 60^0}{\tan 30^0} = \frac{\omega L}{R} \times \frac{1}{\frac{1}{\omega CR}} = \omega^2 LC$$

$$\Rightarrow \frac{\sqrt{3}}{1/\sqrt{3}} = \omega^2 \times 60\times10^{-3}\times0.5\times10^{-6} \Rightarrow \omega = 10^4$$

As $\omega = 2\pi\upsilon$

Or $2\pi\upsilon = 10^4 \Rightarrow \upsilon = \frac{10^4}{2\pi}$ Hz

19. (3)

$(3.20 + 4.80) \times 10^5 = 8.00 \times 10^5$

The number of significant figures is 3.

20. (3)

$$\text{Apparent depth} = \frac{\text{Real depth}}{\mu}$$

$\therefore$ Distance of object from the mirror,

$$\mu = -\left(15 + \frac{33.25}{1.33}\right) = -(15 + 25) = -40 \text{ cm}$$

Distance of image from the mirror

$$v = -\left(15 + \frac{25}{1.33}\right) = -(15 + 18.8) = -33.8\text{cm} \approx -34\text{cm}$$

According to mirror formula

$$\frac{1}{\mu} + \frac{1}{v} = \frac{1}{f} \therefore \frac{1}{-40} + \frac{1}{-34} = \frac{1}{f}$$

On solving, we get, f = -18.4 cm ≈ -20 cm

21. (3)

Here, $U = -\dfrac{k}{2r^2}$

Force acting on the particle, $F = -\dfrac{dU}{dr} = \dfrac{k}{r^3}$

This force provides necessary centripetal force.

So, $\dfrac{mv^2}{r} = \dfrac{k}{r^3}; mv^2 = \dfrac{k}{r^2}$

Kinetic energy of particle, $K = \dfrac{1}{2}mv^2 = \dfrac{k}{2r^2}$

Total energy of the particle

$$= U + K = -\frac{k}{2r^2} + \frac{k}{2r^2} = 0$$

22. (4)

Intensity at any point on the screen is

$$I = 4I_0 \cos^2 \frac{\phi}{2}$$

Where I_0 is the intensity of either wave and ϕ is the phase difference between two waves.

Phase difference, $\phi = \dfrac{2\pi}{\lambda} \times$ Path difference

When path difference is λ, then

$$\phi = \frac{2\pi}{\lambda} \times \lambda = 2\pi$$

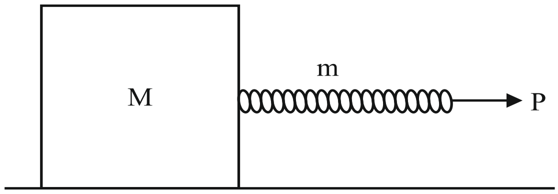
$$\therefore I = 4I_0 \cos^2\left(\frac{2\pi}{2}\right) = 4I_0 \cos^2(\pi)$$

$$= 4I_0 = K \ldots.(i)$$

When path difference is $\dfrac{\lambda}{3}$, then

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3} \quad \therefore I = 4I_0 \cos^2\left(\frac{2\pi}{3}\right) = \frac{K}{4}$$

23. (4)



If a is the acceleration produced in the system, then

$$a = \frac{P}{(M + m)} \qquad \ldots (i)$$

The force exerted by the rope on the block is

$$F = Ma = \frac{MP}{(M + m)}$$

(Using (i)

24. (4)

As per question

$$e(4V_0) = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) \quad \ldots..(i)$$

and

$$eV_0 = \frac{hc}{3\lambda} - \frac{hc}{\lambda_0} = hc\left(\frac{1}{3\lambda} - \frac{1}{\lambda_0}\right) \quad \ldots(ii)$$

Dividing eqn. (i) by eqn. (ii), we get

$$4 = \frac{\frac{1}{\lambda} - \frac{1}{\lambda_0}}{\frac{1}{3\lambda} - \frac{1}{\lambda_0}} \text{ or } 4\left(\frac{1}{3\lambda} - \frac{1}{\lambda_0}\right) = \left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$\text{Or } \frac{4}{3\lambda} - \frac{4}{\lambda_0} = \frac{1}{\lambda} - \frac{1}{\lambda_0} \text{ or } \frac{1}{3\lambda} = \frac{3}{\lambda_0} \text{ or } \lambda_0 = 9\lambda$$

25. (2)

Area of the loop $\hat{k}$

$$A = \left[a^2 + 4 \times \frac{\pi\left(\frac{a}{2}\right)^2}{2}\right]\hat{k} = \left[a^2 + \frac{\pi a^2}{2}\right]\hat{k}$$

Therefore, the magnetic moment of the current loop is

$$M = I \times A = I\left[a^2 + \frac{\pi a^2}{2}\right]\hat{k} = \left[1 + \frac{\pi}{2}\right]Ia^2\hat{k}$$

26. **(3)**

The kinetic energy of an object just after it hits the ground = 50% of K.E. of the object

$$\frac{1}{2}mv'^2 = \frac{1}{2}\times\frac{1}{2}mv^2 \Rightarrow v' = \frac{v}{\sqrt{2}}$$

$$e = \frac{\text{Relative velocity after collision}}{\text{Relative velocity before collision}} = \frac{v'}{v} = \frac{1}{\sqrt{2}}$$

When a ball dropped from a height h, total distance covered at

$$t \to \infty, S = h\left[\frac{1+e^2}{1-e^2}\right], S = h\left[\frac{1+1/2}{1-1/2}\right] = 3h$$

27. **(1)**

As 10^{10} holes enter the emitter in 10^{-6} s, so the emitter current is

$$I_E = \frac{N_h e}{t} = \frac{10^{10}\times1.6\times10^{-19}C}{10^{-6}s} = 1.6\times10^{-3}A = 1.6mA$$

Since 2% of holes is lost in the base, so the base current is

$$I_B = 2\% \text{ of } I_E = \frac{2}{100}\times1.6\text{ mA} = 0.032mA$$

In a transistor, $I_E = I_B + I_C$

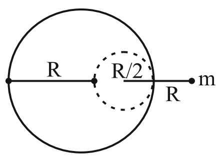
$$\therefore\ I_C = I_E - I_B = 1.6\text{ mA} - 0.032\text{ mA} = 1.568\text{ mA}$$

The current amplification factor,

$$\beta = \frac{I_C}{I_B} = \frac{1.568\text{ mA}}{0.032\text{ mA}} = 49$$

28. **(1)**

Given : Radius of solid sphere = R, radius of spherical cavity = R/2



$$F = \frac{GMm}{(2R)^2} = \frac{GMm}{4R^2}$$

F'= F – Force experienced by M' due to cavity

$$F' = F - \frac{G.\frac{M}{8}m}{\left(\frac{3R}{2}\right)^2} = \frac{GMm}{4R^2} - \frac{GMm}{18R^2}$$

$$F' = \frac{GMm}{R^2}\left[\frac{9-2}{36}\right] = \frac{GMm}{R^2}.\frac{7}{36} \qquad ....(ii)$$

Using equation (i) and (ii), we get

$$\therefore\ \frac{F'}{F} = \frac{7\times4}{36\times1} = \frac{7}{9}$$

29. **(1)**

Initial magnetic flux through the coil,

$$\phi_i = B_H A\cos\theta = 3.0\times10^{-5}\times\left(\pi\times10^{-2}\right)\times\cos0^0 = 3\pi\times10^{-7}$$

Final magnetic flux after the rotation,

$$\phi_f = 3.0\times10^{-5}\times\left(\pi\times10^{-2}\right)\times\cos180^0 = -3\pi\times10^{-7}\text{ Wb}$$

Induced emf, $\varepsilon = -\frac{Nd\phi}{dt} = -N\frac{(\phi_f - \phi_i)}{t}$

$$= \frac{-500\left(-3\pi\times10^{-7} - 3\pi\times10^{-7}\right)}{0.25}$$

$$\varepsilon = \frac{500\left(6\pi\times10^{-7}\right)}{0.25} \approx 4\times10^{-3}V$$

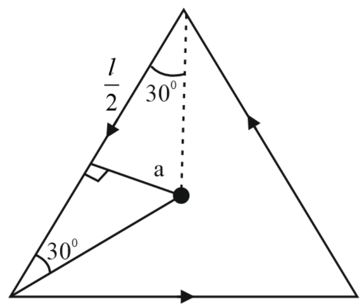
30. **(1)**

$$B_{net} = 3\frac{\mu_0 I}{4\pi a}\left(\cos30^0 + \cos30^0\right)$$

$$= \frac{3\times\left(10^{-7}\right)\times1}{\frac{\left(4.5\times10^{-2}\right)}{\left(2\sqrt{3}\right)}}\left(2\times\frac{\sqrt{3}}{2}\right)$$

$$\left(\because\ \tan30^0 = \frac{a}{(l/2)}, a = \frac{l}{2}\tan30^0 = \frac{l}{2\sqrt{3}}\right)$$

$$B_{net} = \frac{2\times9\times10^{-5}}{4.5} = 4\times10^{-5}\ \text{Wb/m}^2$$



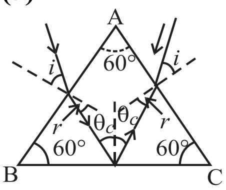
Category - 2

1. **(1)**

$$\left(\frac{g}{R}\right)^{1/2} = \left\{\frac{[LT^{-1}]}{[L]}\right\} = [T^{1/2}]^{1/2} = [T^{-1}]$$

= Angular speed

2. **(3)**



Total deviation = $(i - r) + (180 - 2\theta_c) + (i - r) = 112°$ as $r = 60 - \theta_c$

$2i - 120 + 2\theta_c + 180 - 2\theta_c = 112°$

$\Rightarrow 2i = 52°, i = 26°$

3. **(1)**

Heat carried increases to 2 times. Therefore, new net thermal resistance will become half,

$$\therefore\ R' = \frac{R}{2} = \frac{R_1R_2}{2(R_1+R_2)}\quad \left(\because R = \frac{R_1R_2}{(R_1+R_2)}\right)$$

or $$\frac{(3l/KA)(l/K'A)}{(3l/KA)+(l/K'A)} = \frac{(3l/KA)(l/KA)}{2\left(\frac{3l}{KA}+\frac{l}{KA}\right)}$$

Solving this, we get $K' = \frac{7}{3}K$.

4. **(1)**

Given, $x = 36t$ and $2y = 96t - 9.8t^2$

or $y = 48t - 4.9t^2$

Let the initial velocity of projectile be u and angle of projection is θ. Then initial horizontal component of velocity,

$$u_x = u\cos\theta = \left(\frac{dx}{dt}\right)_{t=0} = 36$$

i.e., $u\cos\theta = 36$

intial vertical component of velocity.

$$u_y = u\sin\theta = \left(\frac{dy}{dt}\right)_{t=0} = 48$$

i.e. $u\sin\theta = 48$

From (i) and (ii), we get

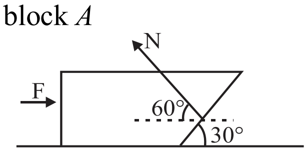
$$\tan\theta = \frac{48}{36} = \frac{4}{3}\ \therefore \sin\theta = \frac{4}{5}$$

Or $$\theta = \sin^{-1}\left(\frac{4}{5}\right)$$

5. **(4)**

Acceleration of two mass system is $a = \frac{F}{2m}$ leftward

FBD of block *A*



$N\cos 60° - F = ma = \frac{mF}{2m}$ solving

$N = 3F$

Category - 3

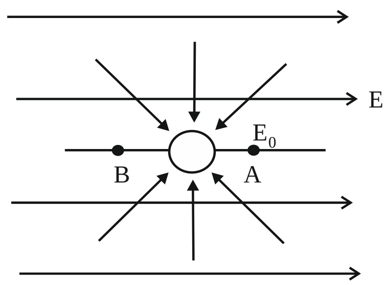
1. **(3)**

Suppose uniform electric field is E and due to negative point charge at a nearby point, electric field is E_0.

We know that electric field intensity is a vector quantity and follow the vector addition rule.

At point A, E and E_o are in opposite direction, thus net electric field decreases.

At point B, E and E_0 are in the same direction, thus the net electric field increases.



Therefore, at a nearby point, electric field may increase or may decrease.

Hence option (3) is correct.

2. **(2)**

We know that the value of acceleration due to gravity decreases when we go up from the surface of the Earth. If we take the into account the effect of bulging of the Earth due to its rotation, we can say that acceleration due to gravity is maximum at the poles and minimum at the equator.

So, there are points above both the poles where the value of g is equal to its value at the equator.

3. **(2), (4)**

The average power delivered by an AC source is given by,

$P_{avg} = V_{rms} I_{rms} \cos\Theta$

Given:

$V_{rms} = 100$ V

$I_{rms} = 10$ A

$\Rightarrow P_{avg} = 1000 \cos\Theta$

$\therefore \Theta \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

$\Rightarrow \cos\Theta \in (0, 1)$

$\therefore\ 0 \le P_{avg} \le 1000$

4. **(1), (2)**

For an elastic spring, the work done is equal to the negative of the change in its potential energy. When the spring was naturally compressed or stretched by a distance x, its potential energy is given by $(P.E.)_r = \frac{1}{2}kx^2$.

When it finally comes to its natural length, its potential energy is given by $(P.E.)_f = 0$.

$$\therefore \text{ Work done} = -\left[(P.E.)_f - (P.E.)_i\right]$$

$$= -\left[0 - \frac{1}{2}kx^2\right] = \frac{1}{2}kx^2$$

5. **(1), (4)**

In a resistor of resistance R, current I is passed for time t then the thermal energy produced in the resistor will be given by $H = i^2RL$.

As the resistors are in series, the current through them will be same. Thus, the amout of thermal energy produced in the resistors is same. The rise in the temperature of the resistance will depend on the shape and size of the resistor. Thus, the rise I the temperature of the two resistances may be equal.