30/01/2024
Evening

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Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2024 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 90 questions. Each subject (PCM) has 30 questions. The maximum marks are 300.

(3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.

(4) **Section - A :** Attempt all questions.

(5) **Section - B :** Attempt any 05 questions out of 10 Questions.

(6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

(7) **Section - B (21 – 30) contains** 10 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

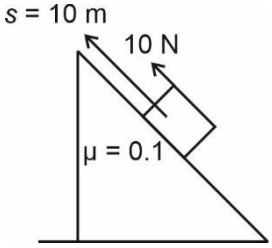
PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. A block of mass 1 kg is ascended on inclined plane by distance of 10 m as shown in diagram, with help of force of 10 N along the incline. Find work done against the friction.



(1) 10 J (2) $5\sqrt{3}$ J

(3) 5 J (4) $(10-5\sqrt{3})$ J

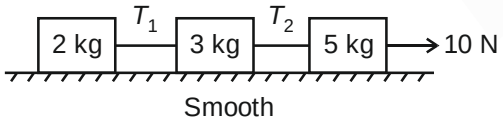
Answer (3)

Sol. $f = \mu mg \cos 60°$

$= 0.1 \times 1 \times 10 \times \frac{1}{2} = 0.5$ N

$W = fs\cos\theta = .5 \times 10 \cos 180 = -5$ J

2. A force of 10 N is applied on a three block system as shown. Find the two tensions T_1 and T_2.



(1) 2 N, 5 N

(2) 5 N, 2 N

(3) 3 N, 4 N

(4) 4 N, 3 N

Answer (1)

Sol. $a = \frac{F_{net}}{M} = \frac{10}{10} = 1\ m/s^2$

$\Rightarrow T_1 = 2\ kg \times 1\ m/s^2 = 2$ N

and $T_2 = (2+3)\ kg \times 1\ m/s^2 = 5$ N

3. The slope of graph between stopping potential (V_0) and frequency of incident photon (f) in photoelectric effect is (h = planck's constant, e = charge on electron)

(1) $\frac{h}{e}$

(2) $\frac{h}{2e}$

(3) $\frac{2h}{e}$

(4) $\frac{e}{h}$

Answer (1)

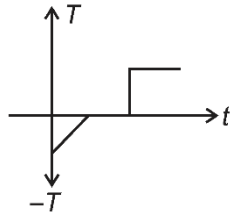
Sol. From Einstein photoelectric equation

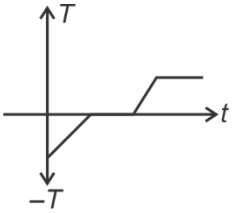
$hf = \phi_0 + eV_0$

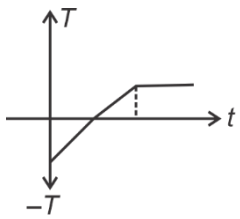
$V_0 = \frac{h}{e}f - \frac{\phi}{e}$

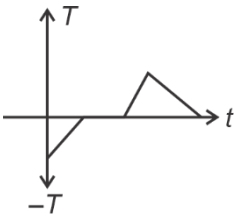
$\therefore$ Slope $= \frac{h}{e}$

4. Ice at temperature –10°C is converted to steam at 100°C, the curve plotted between temperature (T) and time (t) when it is being heated by constant power source is

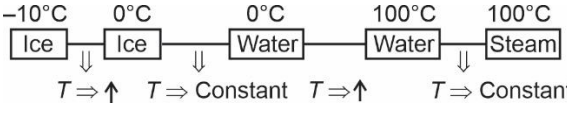
(1) 

(2) 

(3) 

(4) 

Answer (2)

Sol. 

5. Two particles are projected from a tower of height 400 m & angles 45° & 60° with horizontal. If they have same time of flight, find the ratio of their velocities.

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

(2) $\sqrt{\frac{5}{2}}$

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

(4) 1

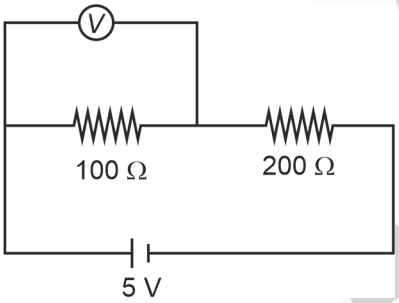
Answer (1)

Sol. For time of flight to be same they have same velocity along *y*-axis.

$v_1 \sin 45 = v_2 \sin 60$

$\frac{v_1}{v_2} = \frac{\sqrt{3}}{\sqrt{2}}$

6. In given circuit, reading of voltmeter is 1 V, then resistance of voltmeter is

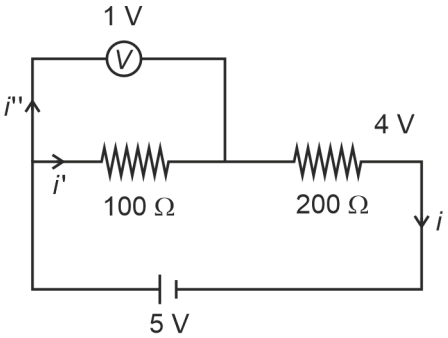


(1) 100 Ω (2) 200 Ω

(3) $200\sqrt{5}$ Ω (2) 50 Ω

Answer (1)

Sol.



$i = \frac{4}{200}$ A

$i' = \frac{1}{100}$ A

$i'' = i - i'$

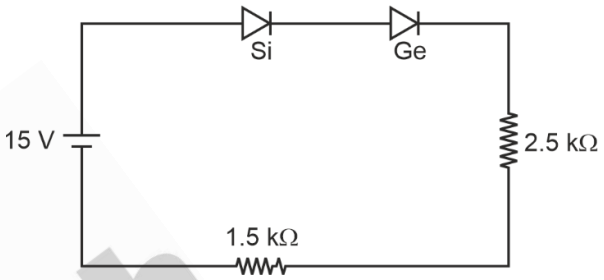
$= \frac{4}{200} - \frac{1}{100}$

$i'' = \frac{2}{200}$ A

$R_V i'' = 1$ volt

$R_V = \frac{1}{2} \times 200 = 100\ \Omega$

7. In the circuit shown if the potential drop in forward bias across Si and Ge diodes are 0.7 V and 0.3 V, find the potential difference across 2.5 kΩ resistor.



(1) 9.25 V (2) 6.25 V

(3) 8.75 V (4) 9.75 V

Answer (3)

Sol. $i = \frac{15 - 0.7 - 0.3}{2.5 + 1.5}$ mA

$= \frac{7}{2}$ mA

$\therefore\ V = 2.5 \times \frac{7}{2}$ volts

$V = 8.75$ volts

8. A point source is placed at origin. Its intensity at distance of 2 cm from source is *I* then intensity at distance 4 cm from the source shall be.

(1) $\frac{I}{2}$

(2) $\frac{I}{16}$

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

(4) *I*

Answer (3)

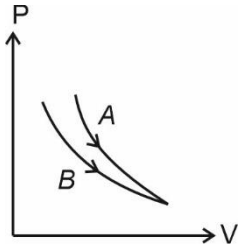
Sol. $I = \frac{\rho}{4\pi r^2}$

$\frac{I_1}{I_2} = \frac{4^2}{2^2}$

$\frac{I}{I_2} = 4$

$I_2 = \frac{I}{4}$

9. The Pressure (P) versus volume (V) of thermodynamic process shown in figure. The select the correct options (Take $\gamma = 1.1$)



(1) For process A : PV = constant

For process B : PV^{γ} = constant

(2) For process A : $PV^{\frac{1}{\gamma}}$ = constant

For process B : PV = constant

(3) For process A : $PV^{1.05}$ = constant

For process B : PV^{γ} = constant

(4) For process A : $PV^{1.2}$ = constant

For process B : PV = constant

Answer (4)

Sol. (Slope of *A*) > (Slope of *B*)

For PV^{γ} = constant

Slope = $-x\left(\frac{P}{V}\right)$

10. Voltage across a 5Ω resistor is given as $V = 200\sin(100\pi t)$. Find out time required for current through it to change from $\frac{i_0}{2}$ to i_0 [i_0 is peak current]

(1) $\frac{1}{300}$ s (2) $\frac{1}{600}$ s

(3) $\frac{1}{150}$ s (4) $\frac{1}{1200}$ s

Answer (1)

Sol. Angle traversed by phasor = 60°

$\Rightarrow \Delta t = \frac{T}{6} = \frac{\pi}{3\times 100\pi}$

$= \frac{1}{300}$ s

11. A nucleus of mass *M* breaks into 3 nuclei with a mass defect of Δm. Find the speed of each daughter nuclei if they have equal mass.

(1) $c\sqrt{\frac{6\Delta m}{(M-\Delta m)}}$

(2) $c\sqrt{\frac{2\Delta m}{(M-\Delta m)}}$

(3) $c\sqrt{\frac{3\Delta m}{(M-\Delta m)}}$

(4) $c\sqrt{\frac{\Delta m}{(M-\Delta m)}}$

Answer (2)

Sol. Total kinetic energy = Δmc^2

$\therefore \quad 3\times\frac{1}{2}\frac{(M-\Delta m)}{3}v^2 = \Delta mc^2$

$v^2 = \frac{2\Delta mc^2}{(M-\Delta m)}$

$\therefore \quad v = c\sqrt{\frac{2\Delta m}{(M-\Delta m)}}$

12. In a vernier calliper 49 main scale divisions are equal to 50 vernier scale divisions. If one main scale division is 0.5 mm, then the vernier constant is

(1) 0.01 mm (2) 0.1 mm

(3) 0.1 cm (4) 0.01 cm

Answer (1)

Sol. 49 MSD = 50 VSD

1 VSD = $\frac{49}{50}$ MSD

LC = 1 MSD – 1 VSD

$= \frac{1}{50}$ MSD

$= \frac{1}{50}\times 0.5$ mm

= 0.01 mm

13. 6×10^5 J of electromagnetic energy is incident on a surface in time t_0. Find the total momentum imparted if the surface is completely absorbing.

(1) 2×10^{-3} kg m/s

(2) 10^{-3} kg m/s

(3) 10^{-2} kg m/s

(4) 2×10^{-4} kg m/s

Answer (1)

Sol. I : intensity

$$\Rightarrow I \cdot A \cdot t_0 = E$$

$$\Rightarrow n \cdot \frac{hc}{\lambda} \cdot t_0 = E$$

$$\Rightarrow n \cdot \frac{h \cdot t_0}{\lambda} = \frac{E}{c} = \frac{6 \times 10^5}{3 \times 10^8}$$

$$= 2 \times 10^{-3}$$

14. A particle is placed on upward parabolic curve $y = \frac{x^2}{4}$ having co-efficient of friction (μ)= 0.5. What should be maximum height above x-axis so that it does not slip.

(1) $\frac{1}{4}$ m (2) $\frac{1}{2}$ m

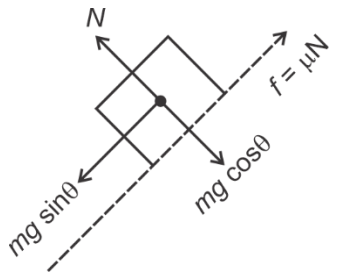
(3) $\frac{1}{3}$ m (4) $\frac{3}{4}$ m

Answer (1)

Sol. $y = \frac{x^2}{4}$

$$\frac{dy}{dx} = \frac{x}{2} = \tan\theta$$

FBD for particle:



at equilibrium = mg $\sin\theta$ = mg $\cos\theta$. μ

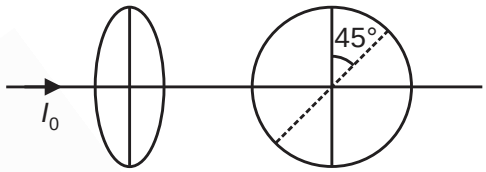
$\tan\theta = \mu$

$$\frac{x}{2} = \mu = \frac{1}{2}$$

x = 1 m

then $y = h = \frac{x^2}{4} = \frac{1}{4}$m

15. Two polaroids are placed at angle of 45° to each other. If unpolarized light of intensity I_0 falls as one polaroid, then intensity of light leaving second polaroid.



(1) $\frac{I_0}{2}$

(2) $\frac{I_0}{2\sqrt{2}}$

(3) $\frac{I_0}{4}$

(4) $\frac{I_0}{8}$

Answer (3)

Sol. From 1st polaroid $\rightarrow \frac{I_0}{2}$

From 2nd polaroid $\rightarrow \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$

16. If a vector is having magnitude equal to that of $\vec{A} = 4\hat{i} + 3\hat{j}$ and is parallel to $\vec{B} = 3\hat{i} + 4\hat{j}$, then if 3 & x are component of this vector in first quadrant, then find x.

(1) 3

(2) 4

(3) 5

(2) 2

Answer (2)

Sol. $\vec{C} = |\vec{A}|\hat{B}$

$$= 5 \times \frac{3\hat{i} + 4\hat{j}}{5}$$

$$= 3\hat{i} + 4\hat{j}$$

$\Rightarrow \quad x = 4$

17. Mass can be expressed as $M = C^p G^{-1/2} \hbar^{1/2}$, where C is speed of light, G is gravitational constant and $\hbar$ is Planck's constant. Find p.

(1) 1

(2) 0.5

(3) –1

(4) –0.5

Answer (2)

Sol. $[C] = [LT^{-1}]$

$[G] = [M^{-1} L^3 T^{-2}]$

$[\hbar] = \left[ML^2T^{-1}\right]$

$[M] = [LT^{-1}]^p \ [M^{-1}L^3T^{-2}]^{-1/2} \ [ML^2T^{-1}]^{1/2}$

$-p + 1 - \frac{1}{2} = 0$

$p = \frac{1}{2}$

18.

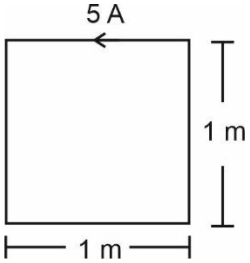
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A square loop of side 1 m is carrying current of 5 A as shown. If the magnetic field at centre is $x\sqrt{2} \times 10^{-7}$ T, find x



Answer (40)

Sol. $B = 4 \times \frac{\mu_0 i}{4\pi(0.5)} (\sin 45° + \sin 45°)$

$= 8\sqrt{2} \times 10^{-7} \times 5$

$= 40\sqrt{2} \times 10^{-7}$ T

22. A planet of mass of $\frac{1}{6}$th of earth's mass, radius of $\frac{1}{3}$rd of earth's radius. If escape speed for earth is 11.2 km/s, then escape speed for the planet shall be _____ km/s (nearest integer).

Answer (8)

Sol. $v_e = \sqrt{\frac{2GM}{r}}$

$v_e' = \sqrt{\frac{2GM'}{r'}}$

$\frac{11.2}{v_e'} = \sqrt{\frac{M(r/3)}{(M/6)r}} = \sqrt{2}$

$\frac{11.2}{\sqrt{2}} = v_e' \approx 8$ km/s

23. An electron in 5th excited state of He^+ atom moves to 1st excited state. Find number of possible spectral lines formed.

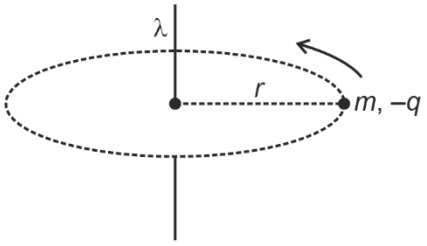
Answer (10)

Sol. Transition is from $6 \rightarrow 2$

$\therefore$ No of line $= \frac{5 \times 4}{2}$

$\Rightarrow$ 10

24. A negatively charged particle (m, $-q$) rotates around a positively charged infinite line charge as shown. Time period of the particle is $\sqrt{\frac{x\pi^3 \varepsilon_0 m r^2}{\lambda q}}$. Find x.



Answer (8)

Sol. $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

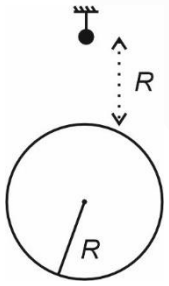
$\Rightarrow \dfrac{\lambda q}{2\pi\varepsilon_0 r} = \dfrac{mv^2}{r}$

$\Rightarrow v = \sqrt{\dfrac{\lambda q}{2\pi\varepsilon_0 m}}$

$\Rightarrow T = \dfrac{2\pi r}{v} = 2\pi r\sqrt{\dfrac{2\pi\varepsilon_0 m}{\lambda q}}$

$= \sqrt{\dfrac{8\pi^3\varepsilon_0 m r^2}{\lambda q}}$

25. A simple pendulum of length 4 m is located at a height R above the surface of earth. The time period of the simple pendulum is $2\pi\sqrt{\dfrac{8}{x}}$ seconds. Find x.



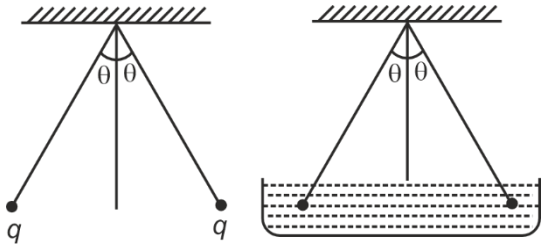
Answer (5)

Sol. $g = \dfrac{g_0}{4}$

$\Rightarrow T = 2\pi\sqrt{\dfrac{l}{g}}$

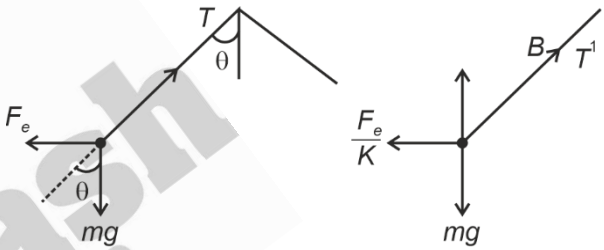
$= 2\pi\sqrt{\dfrac{l}{\frac{g_0}{4}}}$

$= 2\pi\sqrt{1.6}$

26. 

Two identical charged particles connected with light threads from common point as shown. After putting arrangement in liquid, the angular separation between blocks does not change. If relative density of particles is 1.4 and that of liquid is 0.7, dielectric constant of liquid is

Answer (2)

Sol. 

$mg\sin\theta = F_e\cos\theta$ …(i)

$(mg - B)\sin\theta = \dfrac{F_e}{K}\cos\theta$ …(ii)

$\dfrac{mg}{mg - B} = K$

$\dfrac{\sigma}{\sigma - \rho} = K$

$\dfrac{1.4}{1.4 - 0.7} = K$

$\boxed{K = 2}$

27.

28.

29.

30.