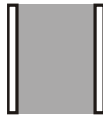


## FINAL JEE-MAIN EXAMINATION – JANUARY, 2020

(Held On Tuesday 07<sup>th</sup> JANUARY, 2020) TIME : 9 : 30 AM to 12 : 30 PM

### PHYSICS

1. A parallel plate capacitor has plates of area  $A$  separated by distance ' $d$ ' between them. It is filled with a dielectric which has a dielectric constant that varies as  $k(x) = K(1 + \alpha x)$  where ' $x$ ' is the distance measured from one of the plates. If  $(\alpha d) \ll 1$ , the total capacitance of the system is best given by the expression :



- (1)  $\frac{AK\epsilon_0}{d} \left(1 + \frac{\alpha d}{2}\right)$       (2)  $\frac{A\epsilon_0 K}{d} \left(1 + \left(\frac{\alpha d}{2}\right)^2\right)$   
 (3)  $\frac{A\epsilon_0 K}{d} \left(1 + \frac{\alpha^2 d^2}{2}\right)$       (4)  $\frac{AK\epsilon_0}{d} (1 + \alpha d)$

NTA Ans. (1)

ALLEN Ans. (1)

2. The time period of revolution of electron in its ground state orbit in a hydrogen atom is  $1.6 \times 10^{-16}$  s. The frequency of revolution of the electron in its first excited state (in  $s^{-1}$ ) is:
- (1)  $6.2 \times 10^{15}$       (2)  $5.6 \times 10^{12}$   
 (3)  $7.8 \times 10^{14}$       (4)  $1.6 \times 10^{14}$

NTA Ans. (3)

ALLEN Ans. (3)

3. A long solenoid of radius  $R$  carries a time ( $t$ )-dependent current  $I(t) = I_0 t(1 - t)$ . A ring of radius  $2R$  is placed coaxially near its middle. During the time interval  $0 \leq t \leq 1$ , the induced current ( $I_R$ ) and the induced EMF ( $V_R$ ) in the ring change as :
- (1) At  $t = 0.5$  direction of  $I_R$  reverses and  $V_R$  is zero  
 (2) Direction of  $I_R$  remains unchanged and  $V_R$  is zero at  $t = 0.25$   
 (3) Direction of  $I_R$  remains unchanged and  $V_R$  is maximum at  $t = 0.5$   
 (4) At  $t = 0.25$  direction of  $I_R$  reverses and  $V_R$  is maximum

NTA Ans. (1)

ALLEN Ans. (1)

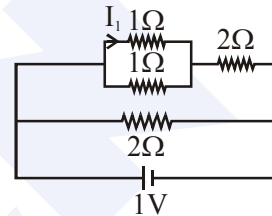
### TEST PAPER WITH ANSWER

4. A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to: (1 HP = 746 W,  $g = 10 \text{ ms}^{-2}$ )
- (1)  $1.7 \text{ ms}^{-1}$       (2)  $2.0 \text{ ms}^{-1}$   
 (3)  $1.9 \text{ ms}^{-1}$       (4)  $1.5 \text{ ms}^{-1}$

NTA Ans. (3)

ALLEN Ans. (3)

5. The current  $I_1$  (in A) flowing through  $1 \Omega$  resistor in the following circuit is :



- (1) 0.5      (2) 0.2      (3) 0.25      (4) 0.4

NTA Ans. (2)

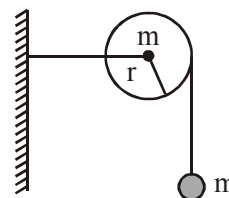
ALLEN Ans. (2)

6. A litre of dry air at STP expands adiabatically to a volume of 3 litres. If  $\gamma = 1.40$ , the work done by air is : ( $3^{1.4} = 4.6555$ ) [Take air to be an ideal gas]
- (1) 90.5 J      (2) 48 J  
 (3) 60.7 J      (4) 100.8 J

NTA Ans. (1)

ALLEN Ans. (1)

7. As shown in the figure, a bob of mass  $m$  is tied by a massless string whose other end portion is wound on a fly wheel (disc) of radius  $r$  and mass  $m$ . When released from rest the bob starts falling vertically. When it has covered a distance of  $h$ , the angular speed of the wheel will be :

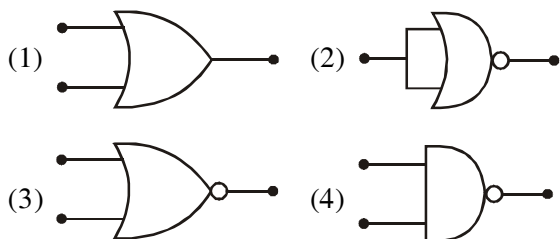


- (1)  $\frac{1}{r} \sqrt{\frac{2gh}{3}}$       (2)  $r \sqrt{\frac{3}{4gh}}$       (3)  $\frac{1}{r} \sqrt{\frac{4gh}{3}}$       (4)  $r \sqrt{\frac{3}{2gh}}$

NTA Ans. (3)

ALLEN Ans. (3)

8. Which of the following gives a reversible operation?



NTA Ans. (2)

ALLEN Ans. (2)

9. If we need a magnification of 375 from a compound microscope of tube length 150 mm and an objective of focal length 5 mm, the focal length of the eye-piece, should be close to :

- (1) 22 mm                      (2) 12 mm  
(3) 33 mm                      (4) 2 mm

NTA Ans. (1)

ALLEN Ans. (1)

10. The radius of gyration of a uniform rod of length  $l$ , about an axis passing through a point

$\frac{l}{4}$  away from the centre of the rod, and perpendicular to it, is :

- (1)  $\frac{1}{8}l$       (2)  $\sqrt{\frac{7}{48}}l$       (3)  $\sqrt{\frac{3}{8}}l$       (4)  $\frac{1}{4}l$

NTA Ans. (2)

ALLEN Ans. (2)

11. If the magnetic field in a plane electromagnetic wave is given by  $\vec{B} = 3 \times 10^{-8} \sin(1.6 \times 10^3 x + 48 \times 10^{10} t) \hat{j} \text{ T}$ , then what will be expression for electric field?

- (1)  $\vec{E} = (9 \sin(1.6 \times 10^3 x + 48 \times 10^{10} t)) \hat{k} \text{ V/m}$   
(2)  $\vec{E} = (3 \times 10^{-8} \sin(1.6 \times 10^3 x + 48 \times 10^{10} t)) \hat{i} \text{ V/m}$   
(3)  $\vec{E} = (60 \sin(1.6 \times 10^3 x + 48 \times 10^{10} t)) \hat{k} \text{ V/m}$   
(4)  $\vec{E} = 3 \times 10^{-8} \sin 1.6 \times 10^3 x + 48 \times 10^{10} t \hat{j} \text{ V/m}$

NTA Ans. (1)

ALLEN Ans. (1)

12. Consider a circular coil of wire carrying constant current  $I$ , forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by  $\phi_i$ . The magnetic flux through the area of the circular coil area is given by  $\phi_0$ . Which of the following option is correct ?

- (1)  $\phi_i = -\phi_0$                       (2)  $\phi_i = \phi_0$   
(3)  $\phi_i < \phi_0$                       (4)  $\phi_i > \phi_0$

NTA Ans. (1)

ALLEN Ans. (1)

13. Speed of a transverse wave on a straight wire (mass 6.0 g, length 60 cm and area of cross-section  $1.0 \text{ mm}^2$ ) is  $90 \text{ ms}^{-1}$ . If the Young's modulus of wire is  $16 \times 10^{11} \text{ Nm}^{-2}$ , the extension of wire over its natural length is :

- (1) 0.02 mm                      (2) 0.04 mm  
(3) 0.03 mm                      (4) 0.01 mm

NTA Ans. (3)

ALLEN Ans. (3)

14. Visible light of wavelength  $6000 \times 10^{-8} \text{ cm}$  falls normally on a single slit and produces a diffraction pattern. It is found that the second diffraction minimum is at  $60^\circ$  from the central maximum. If the first minimum is produced at  $\theta_1$ , then  $\theta_1$  is close to :

- (1)  $20^\circ$       (2)  $45^\circ$       (3)  $30^\circ$       (4)  $25^\circ$

NTA Ans. (4)

ALLEN Ans. (4)

15. A polarizer - analyser set is adjusted such that the intensity of light coming out of the analyser is just 10% of the original intensity. Assuming that the polarizer - analyser set does not absorb any light, the angle by which the analyser need to be rotated further to reduce the output intensity to be zero, is :

- (1)  $18.4^\circ$       (2)  $71.6^\circ$       (3)  $90^\circ$       (4)  $45^\circ$

NTA Ans. (1)

ALLEN Ans. (1)

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16. A satellite of mass  $m$  is launched vertically upwards with an initial speed  $u$  from the surface of the earth. After it reaches height  $R$  ( $R =$  radius of the earth), it ejects a rocket of mass  $\frac{m}{10}$  so that subsequently the satellite moves in a circular orbit. The kinetic energy of the rocket is ( $G$  is the gravitational constant;  $M$  is the mass of the earth):

(1)  $\frac{m}{20} \left( u - \sqrt{\frac{2GM}{3R}} \right)^2$

(2)  $5m \left( u^2 - \frac{119 GM}{200 R} \right)$

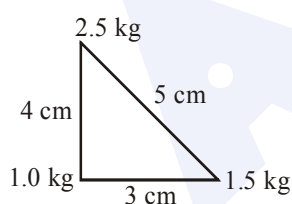
(3)  $\frac{3m}{8} \left( u + \sqrt{\frac{5GM}{6R}} \right)^2$

(4)  $\frac{m}{20} \left( u^2 + \frac{113 GM}{200 R} \right)$

NTA Ans. (2)

ALLEN Ans. (2)

17. Three point particles of masses 1.0 kg, 1.5 kg and 2.5 kg are placed at three corners of a right angle triangle of sides 4.0 cm, 3.0 cm and 5.0 cm as shown in the figure. The center of mass of the system is at a point:



- (1) 1.5 cm right and 1.2 cm above 1 kg mass
- (2) 0.9 cm right and 2.0 cm above 1 kg mass
- (3) 0.6 cm right and 2.0 cm above 1 kg mass
- (4) 2.0 cm right and 0.9 cm above 1 kg mass

NTA Ans. (2)

ALLEN Ans. (2)

18. Two moles of an ideal gas with  $\frac{C_P}{C_V} = \frac{5}{3}$  are mixed with 3 moles of another ideal gas with  $\frac{C_P}{C_V} = \frac{4}{3}$ . The value of  $\frac{C_P}{C_V}$  for the mixture is:

(1) 1.50 (2) 1.42 (3) 1.45 (4) 1.47

NTA Ans. (2)

ALLEN Ans. (2)

19. A LCR circuit behaves like a damped harmonic oscillator. Comparing it with a physical spring-mass damped oscillator having damping constant 'b', the correct equivalence would be:

(1)  $L \leftrightarrow m, C \leftrightarrow \frac{1}{k}, R \leftrightarrow b$

(2)  $L \leftrightarrow \frac{1}{b}, C \leftrightarrow \frac{1}{m}, R \leftrightarrow \frac{1}{k}$

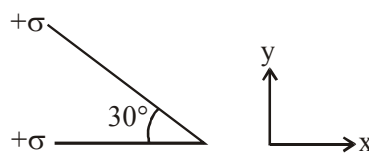
(3)  $L \leftrightarrow m, C \leftrightarrow k, R \leftrightarrow b$

(4)  $L \leftrightarrow k, C \leftrightarrow b, R \leftrightarrow m$

NTA Ans. (1)

ALLEN Ans. (1)

20. Two infinite planes each with uniform surface charge density  $+\sigma$  are kept in such a way that the angle between them is  $30^\circ$ . The electric field in the region shown between them is given by:



(1)  $\frac{\sigma}{\epsilon_0} \left[ \left( 1 + \frac{\sqrt{3}}{2} \right) \hat{y} + \frac{\hat{x}}{2} \right]$

(2)  $\frac{\sigma}{2\epsilon_0} \left[ \left( 1 - \frac{\sqrt{3}}{2} \right) \hat{y} - \frac{\hat{x}}{2} \right]$

(3)  $\frac{\sigma}{2\epsilon_0} \left[ (1 + \sqrt{3}) \hat{y} + \frac{\hat{x}}{2} \right]$

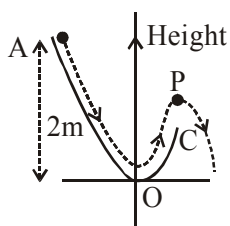
(4)  $\frac{\sigma}{2\epsilon_0} \left[ (1 + \sqrt{3}) \hat{y} - \frac{\hat{x}}{2} \right]$

NTA Ans. (2)

ALLEN Ans. (2)

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21. A particle ( $m = 1 \text{ kg}$ ) slides down a frictionless track (AOC) starting from rest at a point A (height  $2 \text{ m}$ ). After reaching C, the particle continues to move freely in air as a projectile. When it reaches its highest point P (height  $1 \text{ m}$ ), the kinetic energy of the particle (in J) is : (Figure drawn is schematic and not to scale; take  $g=10 \text{ ms}^{-2}$ )\_\_\_\_\_.



NTA Ans. (10)

ALLEN Ans. (10)

22. A Carnot engine operates between two reservoirs of temperatures  $900 \text{ K}$  and  $300 \text{ K}$ . The engine performs  $1200 \text{ J}$  of work per cycle. The heat energy (in J) delivered by the engine to the low temperature reservoir, in a cycle, is\_\_\_\_\_.

NTA Ans. (600)

ALLEN Ans. (600)

23. A beam of electromagnetic radiation of intensity  $6.4 \times 10^{-5} \text{ W/cm}^2$  is comprised of wavelength,  $\lambda = 310 \text{ nm}$ . It falls normally on a metal (work function  $\phi = 2 \text{ eV}$ ) of surface area of  $1 \text{ cm}^2$ . If one in  $10^3$  photons ejects an electron, total number of electrons ejected in  $1 \text{ s}$  is  $10^x$ . ( $hc=1240 \text{ eVnm}$ ,  $1 \text{ eV}=1.6 \times 10^{-19} \text{ J}$ ), then  $x$  is\_\_\_\_\_.

NTA Ans. (10)

ALLEN Ans. (11)

24. A non-isotropic solid metal cube has coefficients of linear expansion as :  $5 \times 10^{-5}/^\circ\text{C}$  along the  $x$ -axis and  $5 \times 10^{-6}/^\circ\text{C}$  along the  $y$  and the  $z$ -axis. If the coefficient of volume expansion of the solid is  $C \times 10^{-16}/^\circ\text{C}$  then the value of  $C$  is \_\_\_\_\_.

NTA Ans. (60)

ALLEN Ans. (60)

25. A loop ABCDEFA of straight edges has six corner points  $A(0,0,0)$ ,  $B(5,0,0)$ ,  $C(5,5,0)$ ,  $D(0, 5, 0)$ ,  $E(0, 5, 5)$  and  $F(0, 0, 5)$ . The magnetic field in this region is  $\vec{B} = (3\hat{i} + 4\hat{k})\text{T}$ . The quantity of flux through the loop ABCDEFA (in Wb) is \_\_\_\_\_ .

NTA Ans. (175)

ALLEN Ans. (175)

