



**FEDERAL PUBLIC SERVICE COMMISSION**  
**COMPETITIVE EXAMINATION-2022**  
**FOR RECRUITMENT TO POSTS IN BS-17**  
**UNDER THE FEDERAL GOVERNMENT**

Roll Number

**PHYSICS, PAPER-I**

<b>TIME ALLOWED: THREE HOURS</b>	<b>PART-I (MCQS)</b>	<b>MAXIMUM MARKS = 20</b>
<b>PART-I(MCQS): MAXIMUM 30 MINUTES</b>	<b>PART-II</b>	<b>MAXIMUM MARKS = 80</b>
<b>NOTE: (i) Part-II is to be attempted on the separate Answer Book.</b>		
<b>(ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks.</b>		
<b>(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.</b>		
<b>(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.</b>		
<b>(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.</b>		
<b>(vi) Extra attempt of any question or any part of the question will not be considered.</b>		
<b>(vii) Use of Calculator is allowed.</b>		

**PART – II**

- Q. 2.** (a) A particle of unit mass moves in potential  $V(x) = ax^2 + b/x^2$  where  $a$  &  $b$  are positive constants. Find the angular frequency of small oscillations? (08)
- (b) A hollow spherical shell carries charge density  $\rho = k/r^2$  in region  $a \leq r \leq b$ . Find the electric field in three regions (i)  $r < a$  (ii)  $a < r < b$  (iii)  $r > b$ . (07)
- (c) A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. Determine its angle of projection. (05) **(20)**
- Q. 3.** (a) Assume that a star has uniform density. Show that the gravitational pressure  $P$  is proportional to  $V^{-3/4}$  where  $V$  is volume. (08)
- (b) Derive expressions for potential and electric field associated with point charge  $q$  located near an infinite grounded conducting plane. (07)
- (c) Determine equation of motion of masses attached to the string of at-wood machine by Lagrangian methods. (05) **(20)**
- Q. 4.** (a)  $Q \text{ cm}^3$  of water flows per second through a horizontal tube of uniform bore of radius  $r$  & of length  $L$ . Another tube of half the length but radius  $2r$  is connected in parallel to same pressure head. What will be the total quantity of water flowing / sec through these two tubes? (08)
- (b) A linear quadruple is an arrangement of a system of charges which consist of  $-2Q$  at the origin and  $+Q$  at the two point  $(\pm d, 0, 0)$ . Show that at distances much greater than (*i.e.*  $r \gg d$ ), the potential may be written in the approximate form
- $$V = \frac{Qd^2}{4\pi\epsilon_0 r^3} (3 \cos^2 \theta - 1), r^2 \gg d^2$$
- (c) Two soap bubbles with radii  $r_1$  and  $r_2$  coalesce to form a bigger bubble of radii  $r$ . Show that  $r = (r_1^2 + r_2^2)^{1/2}$ . (05) **(20)**

## PHYSICS, PAPER-I

- Q. 5.** (a) Explain wave function. Derive wave formula and explain phase and group velocity. (08)
- (b) Two semi-infinite grounded metal plates parallel to each other and to the  $xz$ -plane are located at  $y = 0$  and  $y = a$  planes, respectively. The left ends of these two plates at  $x = 0$ , are closed off by a strip of width  $a$  and extend to infinity in the  $z$ -direction. The strip is insulated from both the plates and is maintained at a specific potential  $V_0(y)$ . Find the potential distribution in the slot. (07)
- (c) A two level system has energies  $0$  &  $E$ . The level with zero energy is non-degenerate while the level with energy  $E$  is triply degenerate. Find the mean energy of a classical particle in this system at temperature  $T$ . (05) (20)
- Q. 6.** (a) Explain the particle in finite potential well with all possible cases and solutions and make a comparison with infinite potential well. (08)
- (b) The potential  $V_0(\theta)$  is specified on the surface of a hollow sphere, of radius  $R$ . Find potential inside the sphere. (07)
- (c) A particle is confined to region  $x > 0$  by a potential which increases linearly as  $u(x) = u_0x$ . Find the mean position of particle at temperature  $T$ . (05) (20)
- Q. 7.** (a) When a gas expands adiabatically its volume is doubled while its absolute temperature is decreased by a factor 1.32. Compute number of degree of freedom of gas molecule? (08)
- (b) State and prove Ampere's Law. (07)
- (c) Find the rms speed of oxygen molecules at  $0^\circ\text{C}$ ? (05) (20)
- Q. 8.** (a) An ensemble of non-interacting spin  $-1/2$  particles is in contact with a heat bath at temperature  $T$  & is subjected to an external magnetic field. Each particle can be in one of the two quantum states of energies  $\epsilon_0$ . If the mean energy per particle is  $-\epsilon_0/2$ , then find free energy per particle? (08)
- (b) Derive the electromagnetic wave equation in vacuum and also describe the properties of monochromatic electromagnetic waves. (07)
- (c) Discuss adiabatic demagnetization using TDS equations mathematically in detail? (05) (20)

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**PHYSICS, PAPER-II**

**TIME ALLOWED: THREE HOURS**  
**PART-I(MCQS): MAXIMUM 30 MINUTES**

**PART-I (MCQS)**  
**PART-II**

**MAXIMUM MARKS = 20**  
**MAXIMUM MARKS = 80**

- NOTE: (i) Part-II is to be attempted on the separate Answer Book.**  
**(ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks.**  
**(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.**  
**(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.**  
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**(vii) Use of Calculator is allowed.**

**PART – II**

- Q. 2. (a)** An electric dipole, comprising a positive charge  $q$  and a negative charge  $-q$ , is placed on the  $x$ -axis. Each charge is at the same distance from the origin. The total separation between the charges is  $2a$ . Calculate the electric field  $E$  due to these charges along the  $y$ -axis at the point P, which is at a distance  $y$  from the origin. Assume  $y \gg a$  ( $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ ). (10)
- (b)** Write down a mathematical expression to evaluate electric field  $E$  at a distance  $r$  from the source charge  $Q$  in vector form. Sketch the graph of  $E$  as a function of  $r$ . (6)
- (c)** Define electric field and a dipole. (4) **(20)**
- Q. 3. (a)** Discuss photoelectric effect and establish Einstein's equation for the photoelectric effect. (10)
- (b)** Describe the inadequacy of the wave theory of light to explain the effect. (6)
- (c)** A photon of energy 12 eV falls on a certain metal plate whose work function is 4.15 eV. Find the stopping potential. The mass and charge of electron are  $9.11 \times 10^{-31} \text{ kg}$  and  $1.6 \times 10^{-18} \text{ C}$  respectively and the value of Planck's constant is  $6.64 \times 10^{-34} \text{ J} \times \text{s}$ . (4) **(20)**
- Q. 4. (a)** Discuss intrinsic and extrinsic semiconductors. (10)
- (b)** Describe the properties of diamagnetic, paramagnetic and ferromagnetic materials. (6)
- (c)** Briefly discuss the Landé  $g$  factor. (4) **(20)**
- Q. 5. (a)** Four charged particles of charge  $q$ ,  $2q$ ,  $3q$  and  $4q$  are at the corners of a square of side ' $a$ ' arranged in counter clockwise direction. Determine **(i)** the electric field at the location of charge  $q$  and **(ii)** the total electric force exerted on  $q$ . (8)
- (b)** A parallel plate capacitor has a plate separation of 1 mm. Calculate the surface area of each plate of the capacitor to obtain a capacitance of 1F. Is it possible to produce such a capacitor in the lab? Comment. ( $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ ). (6)
- (c)** Define (6) **(20)**
- (i) Capacitance      (ii) The unit of capacitance      (iii) Surface charge density**