



**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 Atwood 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 quadrupole is an arrangement of a system of charges which consist of  $-2Q$  at the origin and  $+Q$  at the two points  $(\pm d, 0, 0)$ . Show that at distances much greater than (*i.e.*  $r \gg d$ ), the potential may be written in the approximate form
- $$V = \frac{Qd^2}{4\pi\epsilon_0 r^3} (3 \cos^2 \theta - 1), r \gg d$$
- (c) Two soap bubbles with radii  $r_1$  and  $r_2$  coalesce to form a bigger bubble of radius  $r$ . Show that  $r = (r_1^3 + r_2^3)^{1/3}$ . (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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