Civil Services (Main) Examination, 2000

PHYSICS

(Paper I)

Time Allowed : Three Hours **Maximum Marks : 300**

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.
Candidate has to attempt FIVE questions in all.
Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.
All questions carry equal marks.
Wherever any assumptions are made for answering a question, they must be clearly indicated.
Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any THREE of the following:

(a) What is 'Lorentz Contraction'? A spaceship of rest length 100 mm takes 4 μs to pass an observer on Earth. What is its velocity relative to the Earth?

(b) The mass of the Moon is about 0.13 times the mass of the Earth. The distance from the centre of the Moon to the centre of the Earth is 60 times the radius of the Earth. Taking the Earths radius to be 6378 km. find out the distance of the centre of mass of the Earth - Moon system from the centre of the Earth.

(c) How does the resolving power of a microscope differ from that of a telescope? Find the resolving power of an electron microscope that uses 15 keV electrons, assuming that this is equal to the electron wavelength.

(d) Define the efficiency of a Carnot Engine. An engine is designed to have an efficiency of 25% and to absorb heat at a temperature of 267° C. Find the maximum temperature at which it can exhaust heat.

2. (a) Using Bernaulli's principle indicate how to compute the thrust on a rocket produced by the escape of its exhaust gases.

(b) An aeroplane makes a complete half circle of 50 m radius towards left when flying at 200 km / hour. The rotary engine and the propeller of the plane weigh 400 kg having a radius of gyration of 30 cm. The engine rotates at 2400 rpm clockwise viewing from the rear. Find the gyroscopic couple on the aircraft.

(c) Explain the evaporation of a liquid at a temperature below its boiling point on the basis of kinetic theory of matter.

3. (a) What is the most probable distribution of speeds in a large number of molecules of a gas and indicate the steps for its derivation.

(b) A top is spinning about its axis of symmetry. If its spin angular momentum is large compared to the change caused by the applied torque the top precesses. If it is not spinning, the top would tip over Show what happens in between, when the top spins slowly. Derive an approximate expression for the angular speed of the precessional motion.

(c) When fixed at both ends, a wire under tension of 900 N and having a linear density 10^{-2} kg/m is resonant at the frequency of 420 Hz. The next higher frequency at which it resonates is 490 Hz. What is the length of the wire.

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4. **(a)** Derive an expression for the mass-energy equivalence using the principle of special relativity.

(b) Neptune's period of revolution is 165 yr. What is the average radius of Neptune's orbit in terms of the Sun-Earth distance?

(c) Four perfect polarizing plates are stacked so that the axis of each is turned 30° clockwise with respect to the preceding plate: the last plate is crossed with the first. How much of the intensity of an incident unpolarized light is transmitted by the stack?

SECTION 'B'

5. Answer any THREE of the following:

(a) The case of a Simple Harmonic Progressive Wave traversing through a medium is expressed as

$$y=4\times10^{-5}\sin(600\pi t+\varphi)$$

Determine (i) amplitude of vibration of the particles. (ii) wavelength of the sound wave and (iii) the phase difference between the particles situated at a distance of 22 cm. (The sound velocity in the medium is 3.4×10^4 cm/s).

(b) Show that the combined effects of translation of the centre of mass and rotation about an axis through the centre of mass are equivalent to a pure rotation with the same angular speed about an axis through the point of contact of a rolling body.

(c) A tank whose capacity is 0.1 m^3 contains helium at a pressure of 10 atmospheres and a temperature of 20°C. A rubber weather balloon is inflated with this helium. (i) When the pressure of helium in the balloon is 1 atmosphere, its temperature is –40° C. Find the volume of the balloon. (ii) Eventually the helium in the balloon absorbs heat from the air around it and returns to 20° C. Find the volume of the balloon at this time.

(d) Ram and Shyam are two skaters weighing 40kg and 60 kg respectively. Ram travelling at 4 m/s meets Shyam travelling at 2 m/s in opposite direction and collides head-on. (i) If they remain in contact what is their final velocity? (ii) How much kinetic energy is lost?

6. **(a)** What is an adiabatic process? Give three engineering examples of adiabatic processes which are in common use.

(b) Show that Simple Harmonic Motion can be described as the projection on its diameter of a uniform circular motion.

(c) The maximum pressure variation P that the human ear can tolerate in loud sounds is about 28 nt/m^2. Normal atmospheric pressure is about 100,000 nt/m^2. Find the corresponding maximum displacement for a soundwave in air having a frequency of 100 cycles/second. (Take velocity of sound in air as 331 m/sec. and density of air = 1.22 kg/m^3)

7. **(a)** Explain in detail how one can obtain fringes with the Michelson Interferometer using incandescent lamps.

(b) How one can obtain the various types of information about the physical conditions on the stellar surface using thermal ionization equation to interpret the stellar spectra

(c) A book sits on a horizontal board that is undergoing simple harmonic motion with amplitude of 1 m. The coefficient of friction between the book and the board is $\mu=0.5$. Find the frequency of the motion of the board at which the book is about to slip.

8. Write short notes on the following: (i) Coriolis force (ii) Clausius - Clapeyron Equation (iii) Debyes's theory of specific heat (iv) Adiabatic demagnetisation (v) Holography

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