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RAMANUJA IAS ACADEMY

ANSWER BOOKLET PHYSICS (PhTS18)

TEST CODE : 601

TIME ALLOWED: 3 hours **TOTAL MARKS: 250**

Roll no	.....
Subject	**PHYSICS PAPER- 1** .....
Module	**MECHANICS -1** .....

Date	.....
Time	.....

Qn No.	Maximum Marks	Marks Obtained	Qn No.	Maximum Marks	Marks Obtained	Qn No.	Maximum Marks	Marks Obtained
1(a)			4(b)			7(c)		
1(b)			4(c)			7(d)		
1(c)			4(d)			8(a)		
1(d)			5(a)			8(b)		
1(e)			5(b)			8(c)		
2(a)			5(c)			8(d)		
2(b)			5(d)					
2(c)			5(e)			2(e)		
2(d)			6(a)			3(e)		
3(a)			6(b)			4(e)		
3(b)			6(c)			6(e)		
3(c)			6(d)			7(e)		
3(d)			7(a)			8(e)		
4(a)			7(b)					

Total Marks: **Signature of the Examiner:**

QUESTION PAPER SPECIFIC INSTRUCTIONS

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

There are EIGHT questions divided in two Sections and printed both in HINDI and in ENGLISH.

Candidate has to attempt FIVE questions in all.

Question Nos. **1** and **5** are compulsory and out of the remaining, THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by each question/part is indicated against it.

Answers must be written in the medium authorized in the Admission Certificate which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in a medium other than the authorized one.

Assume suitable data, if considered necessary, and indicate the same clearly.

Unless and otherwise indicated, symbols and notations carry their usual standard meanings.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

Constants which may be needed

Velocity of light in vacuum (c)	=	$3\times10^{8}\ ms^{-1}$
Mass of electron (m_e)	=	$9{\cdot}11\times10^{-31}\ kg$
Charge of electron (e)	=	$1{\cdot}602\times10^{-19}\ C$
Specific charge of electron $\left(\frac{e}{m_e}\right)$	=	$1{\cdot}76\times10^{11}\ C\ kg^{-1}$
$1\ u = 1$ a.m.u. $= 1{\cdot}6605\times10^{-27}\ kg$	=	931·5 MeV
Rest mass energy of electron ($m_e c^2$)	=	0·5110 MeV
Permittivity in free space (ε_0)	=	$8{\cdot}8542\times10^{-12}\ C^2N^{-1}m^{-2}$
Permeability of free space (μ_0)	=	$4\pi\times10^{-7}\ N\ A^{-2}$
Gas constant (R)	=	$8{\cdot}314\ J\ mol^{-1}\ K^{-1}$
Boltzmann constant (k_B)	=	$1{\cdot}381\times10^{-23}\ J\ K^{-1}$
Planck constant (h)	=	$6{\cdot}626\times10^{-34}\ J\ s$
($\hbar$)	=	$1{\cdot}0546\times10^{-34}\ J\ s$
Bohr magneton (μ_B)	=	$9{\cdot}274\times10^{-24}\ J\ T^{-1}$
Nuclear magneton (μ_N)	=	$5{\cdot}051\times10^{-27}\ J\ T^{-1}$
Fine structure constant (α)	=	1/137·03599
Mass of proton (M_p)	=	$1{\cdot}0072766\ u = 1{\cdot}6726\times10^{-27}\ kg$
Mass of neutron (M_n)	=	$1{\cdot}0086652\ u = 1{\cdot}6749\times10^{-27}\ kg$
Mass of deuteron (M_d)	=	2·013553 u
Mass of α-particle (M_α)	=	4·001506 u
Mass of $^{12}_{6}C$	=	12·000000 u
Mass of $^{16}_{8}O$	=	15·994915 u
Mass of $^{87}_{38}Sr$	=	86·99999 u
Mass of $^{4}_{2}He$	=	4·002603 u

SECTION-A

1 (a) State the conservation laws of mechanical energy, linear momentum and angular momentum. Also state the laws mathematically.

10

1 (b) Check whether the following two forces are conservative or not

(i) $F=(y^2-x^2)i+2xyj$ **(ii)$F= (2xy+z^2)i+x^2 j +2xzk$**

10

1 (d) A mass M is suspended from an elastic string so that on pulling the mass down a little and releasing it, it oscillates up and down, executing a S.H.M. It is found that if an additional mass m is added to M, the time period of oscillation changes in the ratio 5:4. Obtain the ratio m/M.

10

1 (c) Derive the law of addition of relativistic velocities. Use it to prove that under the Lorentz transformation no two velocities can add up to more than the value of the speed of light.

10

1 (e) Find the centre of mass of a homogenous solid hemisphere of radius R.

10

2 (a) If the forces acting on a particle are conservative, show that the total energy of the particle which is the sum of the kinetic and potential energies is conserved.

10

2 (b) Define moment of inertia and radius of gyration. Explain their Physical significance. State laws of (ii) Parallel axis theorem and (iii) perpendicular axis theorem and prove any one of them. (iv) Calculate the moment of inertia of solid cylinder about its own axis of cylindrical symmetry.

20

2 (c) A flat thin uniform disc 'D' of radius a and centre O has of radius b in it at a distance c from O. If its mass be 90 gm and a, b and c equal to 7 cm , 2 cm, 4 cm, respectively , calculate its moment of inertia (i) about an axis through O and perpendicular to its plane, (ii) about an axis through the centre of the hole and perpendicular to its plane and (iii) about an axis passing through O and the centre of the hole.

20

3 (a) Describe briefly the Michelson-Morley experiment and discuss the significance of its null result in the context of the special theory of relativity.

10

3 (b) Write the components of the velocity 4-vector of a particle in an inertial frame S. How does the four velocity transform to another inertial frame S' ? **5+5**

(ii) Show that the operator $\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)$ is invariant under Lorentz transformations. **10**

3 (c) Calculate the percentage contraction in the length of a rod in a frame of reference , moving with velocity 0.8c in a direction (a) parallel to its length (b) at an angle of 30^0 with its length. What is the orientation of the rod in the moving frame of reference.

20

4 (a) Calculate the gravitational self energy of a uniform solid sphere of radius R.

10

4 (b) Assuming that the interior of the earth can be treated as a homogenous spherical mass in hydrostatic equilibrium, express the pressure within the earth as a function of distance r from the centre. Taking radius of the earth, $R=6.3*10^8$ cm and its uniform density, $d = 5.5gm/cm^3$, calculate the pressure at the centre of the earth.

20

4 (c) Derive the expression for centrifugal and Coriolis forces. **10**

4 (d) Consider a fixed inertial frame x' y' z' at the centre of earth and the moving reference frame xyz on the surface of earth. Calculate the expression for effective force F_{eff} as measured in the moving system placed on the surface of earth.

10

SECTION - B

5 (a) Find the velocity and momentum of a particle having rest mass m_0 and kinetic energy equal to two times of its rest mass energy.

10

5 (b) A satellite revolves in a circular orbit around the Earth at a certain height above it. Calculate the time period of revolution of the satellite, if the radius of the Earth is significantly higher than the height at which the satellite revolves.

10

5 (c) State stokes law for motion of a body in viscous medium. Deduce the expression for terminal velocity of a body in viscous fluid.

10

5 (d) A metal wire of length 3 m and diameter 1 mm is stretched by a weight of 10 kg. If Young's modulus for its material be $12.5*10^{11}$ dynes/cm^2 and σ a for it equal to 0.26, calculate the lateral compression produced.

10

5 (e) Show that the Young's modulus (Y) , Bulk modulus (K) and Poisson's ratio (σ) are related by

$$\mathbf{K = \frac{Y}{3(1-2\sigma)}}$$

10

6 (a) Derive Poseuille's equation for liquid flow through a narrow tube. Construct a method for determining coefficient of viscosity of liquid using this equation.

20

6 (b) Two horizontal capillary tubes A and B are connected together in series so that a steady stream of fluid flows through them. A is 0.4 mm in internal radius and 256 cm long. B is 0.3 mm in internal radius and 40.5 cm long . The pressure of the fluid at the entrance is 3 inches of the mercury above the atmosphere. At the exit end of B, it is atmospheric(30 inches of mercury). What is the pressure at the junction of A and B. Consider the fluid is liquid.

15

6 (c) A horizontal pipe of non uniform bore has water flowing through it such that the velocity of flow is 40 cm/s at a point where the velocity of flow is 60 cm/s? (Take g = 980 cm/s^2 and density of water = 1 g/c.c.

15

7 (a) Show that the differential scattering cross-section can be expressed as

$\sigma(\theta) = \frac{s}{\sin(\theta)} \left| \frac{ds}{d\theta} \right|$ **where s is the impact parameter and θ is the scattering angle.**

15

7 (b) Show that in a one dimensional elastic collision the speed of the centre of mass of two particles, m_1 moving with initial speed u_1, and m_2 moving with initial speed u_2 is given by

$$V=\frac{m_1}{m_1+m_2}u_1+\frac{m_2}{m_1+m_2}u_2$$

10

7 (c) Prove that as a result of an elastic collision of two particles under non relativistic regime with equal masses, the scattering angle will be 90°. Illustrate your answer with a vector diagram.

5

7 (d) (i)Calculate the horizontal component of the Coriolis force acting on a body of m ass 0·1 kg moving north ward with a horizontal velocity of 100 ms^{-1} at 30° N latitude on the Earth.

10

(ii) Derive the relativistic length contraction using Lorentz transformation.

10

8 (a) If the maximum possible exhaust velocity of a rocket be 2 km/sec, calculate the ratio $\frac{M_0}{M}$ for it if it is to attain the escape velocity 11.2 km/sec. how long will it take the rocket (starting from rest) to attain this velocity if its rate of change of mass in terms of its initial mss, i.e., $\beta = \frac{1}{10}$

15

8 (b) A particle is moving in a central force field on an orbit given by $r = k\, e^{\alpha\theta}$ where k and α are positive constants, r is the radial distance and θ is the polar angle.

(a) Find the force law for the central force field. (10)

(b) Find θ(t) (10)

(c) Find the total energy (5)

8 (c) Determine the number of degrees of freedom for a rigid body

(i) moving freely in space of three dimensions
(ii) having one point fixed
(iii) having two points ' fixed

10

SPACE FOR ROUGH WORK

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