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COMMON SECOND MID-TERM TEST - 2019

Standard XI

PHYSICS

Reg.No.:

Time: 1.30 hours. Marks: 45

Part - A

I. Choose the correct answer: $10 \times 1 = 10$

1. The time period of a satellite orbiting the earth in a circular orbit is independent of
   a) radius of the orbit
   b) the mass of the satellite
   c) both mass and radius of the orbit
   d) neither the mass nor the radius of the orbit
2. The workdone by the Sun's gravitational force on the Earth is
   a) always zero
   b) always positive
   c) can be positive or negative
   d) always negative
3. A planet moving along an elliptical orbit is closest to the Sun at a distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are linear speeds at these points respectively., then the ratio $\frac{v_1}{v_2}$ is
   a) $\frac{r_2}{r_1}$
   b) $\left(\frac{r_2}{r_1}\right)^2$
   c) $\frac{r_1}{r_2}$
   d) $\left(\frac{r_1}{r_2}\right)^2$
4. At what height from the surface of the earth, the total energy of the satellite is equal to its potential energy at a height 2R from the surface of earth? (R-radius of the earth)
   a) $\frac{R}{4}$
   b) $\frac{R}{2}$
   c) 2R
   d) 4R
5. An earth satellite is moving around the earth in circular orbit, in such case what is conserved?
   a) velocity
   b) linear momentum
   c) angular momentum
   d) none of these
6. If a wire is stretched to double of its original length, then the strain in the wire is
   a) 1
   b) 2
   c) 3
   d) 4
7. With an increase in temperature, the viscosity of liquid and gas respectively will
   a) increase and increase
   b) increase and decrease
   c) decrease and increase
   d) decrease and decrease
8. In a horizontal pipe of non uniform cross section, water flows with a velocity of 1 ms^{-1} at a point where the diameter of the pipe is 20 cm. The velocity of the water at a point where the diameter of the pipe 5 cm is
   a) 8 ms^{-1}
   b) 16 ms^{-1}
   c) 24 ms^{-1}
   d) 32 ms^{-1}
9. A small sphere of radius 2 cm falls from rest in a viscous liquid. Heat produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity is proportional to
   a) 2^2
   b) 2^3
   c) 2^4
   d) 2^5

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10. A body undergoes no change in volume when it is subjected to a tensil force, then the poison ratio is

a) 0.5 b) 0.05 c) 0.25 d) 2.5

Part - B

II. Answer any 4 questions: (Ques.No.16 is compulsory) **4 x 2 = 8**

11. State Newtons law of Gravitation.
12. Why is there no lunar eclipse and solar eclipse every month?
13. Define Elastic limit.
14. State the laws of flotation.
15. Define angle of contact for a given pair of solid and liquid.
16. An unknown planet orbits the sun with distance twice the semi major axis distance of the Earth's orbit. If the Earth's time period is T_1, what is the time period of this unknown planet?

Part - C

III. Answer any 4 questions: (Ques.No.21 is compulsory) **4 x 3 = 12**

17. State the three laws of Kepler's planetary motion.
18. Obtain an expression for gravitational potential energy.
19. Derive an expression for elastic energy stored per unit volume of a wire.
20. Distinguish between streamlined flow and turbulent flow.
21. A metal plate of area 2.5×10^{-4} m² is placed on a 0.25×10^{-3} m thick layer of castor oil. A force of 2.5 N is needed to move the plate with velocity 3×10^{-2} ms^{-1}. Calculate the co-efficient of viscosity of castor oil.

Part - D

IV. Answer all the questions: **3 x 5 = 15**

22. a) Explain the variation of acceleration due to gravity with depth.

(or)

b) Explain in detail the idea of weightlessness using lift as an example.

23. a) Define Escape speed. Obtain the expression for escape speed of an object from a given planetary surface.

(or)

b) State Pascals law and explain the working of Hydraulic lift based on Pascals law.

24. a) Using Stokes law, obtain an expression for terminal velocity of a sphere moving in a highly viscous liquid.

(or)

b) State and prove Bernoulli's theorem for streamlined flow of incompressible, non viscous liquid.

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HIGHER SECONDARY FIRST YEAR
COMMON SECOND MID TERM TEST – NOVEMBER 2019

KEY ANSWER FOR PHYSICS

01. For answers in part II, III and IV like reasoning, explaining, narrating, describing and listing the points students may write in their own words but without changing the concepts and without skipping any point.

02. Answer written only in Black (or) Blue should be evaluated.

Q. No.	Option	Answer
01	b)	the mass of the satellite
02	c)	Can be positive or negative
03	a)	$\frac{r_2}{r_1}$
04	b)	$\frac{R}{2}$
05	c)	Angular momentum
06	a)	1
07	c)	Decrease and increase
08	b)	$16ms^{-1}$
09	d)	2^5
10	a)	0.5

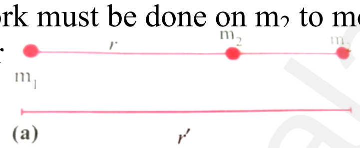
PART - II

01. For all problem type questions correct answer without unit reduce Half Mark
02. For wrong answers with correct unit do not award mark for unit

11	The strength of this force of attraction was found to be directly proportional to the **product of their masses and is inversely proportional to the square of the distance** between them. (or) $\frac{Gm_1m_2}{r^2} = F$	2 1	2
12	**Moon's orbit is tilted 5^0** with respect to Earth's orbit, only during certain periods of the year; the Sun, Earth and Moon align in straight line leading to either lunar eclipse or solar eclipse depending on the alignment.	2	2
13	Maximum stress upto which the body regains its **original shape and size after the removal of deforming force.**	2	2
14	A body will float in a liquid if the weight of the liquid displaced by the immersed part of the body equals the weight of the body.	2	2
15	The angle between the **tangent to the liquid surface** at the point of contact and the **solid surface** is known as the angle of contact.	2	2

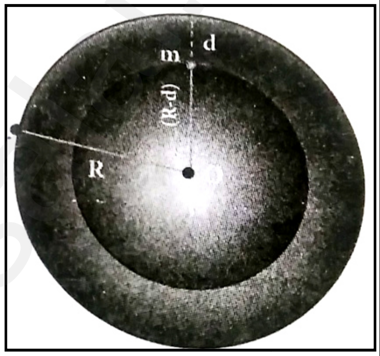
16	$\mathbf{T^2 \propto a^3}$ $\frac{T_1^2}{T_2^2} = \frac{a_1^3}{8a_1^3} = \frac{1}{8}$ $8T_1^2 = T_2^2$ (or) $T_2 = 2\sqrt{T_1}$	**½** **1** **½**	**2**

PART - III

17	**1. Law of orbits:** Each planet moves around the Sun in an elliptical orbit with the Sun at one of the foci. **2. Law of area:** The radial vector (line joining the Sun to a planet) sweeps equal areas in equal intervals of time **3. Law of period:** The square of the time period of revolution of a planet around the Sun in its Elliptical orbit is directly proportional to the cube of the semi-major axis of the ellipse. **(or)** $\mathbf{T^2 \propto a^3}$	**3x1** **1**	**3**
18	1) Two masses m_1 and m_2 are initially separated by a distance r'. Assuming m_1 to be fixed in its position, work must be done on m_2 to move the distance from r' to r as shown in Figur  $dW = \frac{Gm_1m_2}{r^2}dr$ $W = \int_{r'}^{r} dW = \int_{r'}^{r} \frac{Gm_1m_2}{r^2}dr$; $W = -\left(\frac{Gm_1m_2}{r^2}\right)_{r'}^{r}$; $W = -\frac{Gm_1m_2}{r} + \frac{Gm_1m_2}{r'}$	**1** **½** **1½**	**3**
19	When a body is stretched, work is done against the restoring force (internal force). This work done is stored in the body in the form of elastic energy. Consider a wire whose un-stretch length is L and area of cross section is A. $W = \int_0^l F\,dl$ -------------------1 From Young's modulus of elasticity, $Y = \frac{F}{A} \times \frac{L}{l} \Rightarrow F = \frac{Y\,Al}{L}$ --------- 2 Substituting equation (2) in equation (1), we get $W = \int_0^l \frac{Y\,Al}{L}dl = \frac{Y\,Al^2}{L.2} = ½\,.Fl$ $W = \int \frac{Y\,Al'}{L}dl' = \frac{YA}{L}\frac{l'^2}{2}\Big\vert_0^l = \frac{YA}{L}\frac{l^2}{2} = \frac{1}{2}\left(\frac{YAl}{L}\right)l = \frac{1}{2}Fl$ $\frac{\frac{1}{2}Fl}{AL}$ $\frac{1}{2}\frac{F}{A}\frac{l}{L} = \frac{1}{2}$	**½** **1** **1** **½**	**3**
20	**Streamlined flow:** When a liquid flows such that each particle of the liquid passing through a point moves along the same path with the same velocity as its predecessor then the flow of liquid is said to be a streamlined flow. The velocity of the particle at any point is constant. It is also referred to as steady or laminar flow. The actual path taken by the particle of the moving fluid is called a streamline, which is a curve, the tangent to which at any point gives the direction of the flow	**1½ +** **1½**	**3**

	of the fluid at that point. **Turbulent flow:** When the speed of the moving fluid exceeds the critical speed, v_c the motion becomes turbulent. The velocity changes both in magnitude and direction from particle to particle. The path taken by the particles in turbulent flow becomes erratic and whirlpool-like circles called eddy current or eddies.		
21	$\eta = \frac{F\,dx}{A\,dv}$ $= \frac{2.5 \text{ X } 0.25 \text{ X } 10^{-3}}{2.5 \text{ X } 10^{-4} \text{ X } 3 \text{ X } 10^{-2}}$ $= 0.083 \text{ X } \mathbf{10^3\ Nm^{-2}s}$	1 1 1	3

PART - IV

22	a) **Variation of g with depth:**  Consider a particle of mass m which is in a deep mine on the earth. Ex. Coal mines – in Neyveli). Assume the depth of the mine as d. To Calculate g at a depth d, consider the following points. The part of the Earth which is above the radius (R_e – d) do not contribute to the acceleration. The result is proved earlier and is given as $g' = \frac{GM'}{(R_e-d)^2}$ Here M is the mass of the Earth of radius (R_e – d). Assuming the density of earth ρ to be constant, $\rho = \frac{M'}{V'}$; $\frac{M'}{V'} = \frac{M}{V}$ and $M' = \frac{M}{V}V'$ $M' = \left(\frac{M}{\frac{4}{3}\pi R_e^3}\right)\left(\frac{4}{3}\pi(R_e-d)^3\right)$; $M' = \frac{M}{R_e^3}(R_e-d)^3$ $g' = G\frac{M}{R_e^3}(R_e-d)^3 \cdot \frac{1}{(R_e-d)^2}$; upto -- $g' = GM\frac{R_e\left(1-\frac{d}{R_e}\right)}{R_e^3}$ $g' = GM\frac{\left(1-\frac{d}{R_e}\right)}{R_e^2}$ thus $g' = g\left(1-\frac{d}{R_e}\right)$. Here also $g' < g$. As depth increases, g' decreases. Upto --------------------------------------	1 2 2	5
	b) i) When the lift falls (when the lift wire cuts) with downward acceleration a = g, the person inside the elevator is in the state of weightlessness or free fall. ii) As they fall freely, they are not in contact with any surface (by neglecting air friction). The normal force acting on the object is zero. The downward acceleration is equal to the acceleration due to the gravity of the Earth. i.e (a = g). From equation N = m (g − a) we get, a = g ∴ N = m (g – g) = 0. This is called the state of weightlessness.	2 2 1	5

23	a) **Escape speed.** 1) Consider an object of mass M on the surface of the Earth. When it is thrown up with an initial speed v_i , the initial total energy of the object is $E_i = \frac{1}{2} MV_i^2 - \frac{GMM_E}{R_E}$ ---------------- 1 Where M_E, is the mass of the Earth and R_E - the radius of the Earth. The term $-\frac{GMM_E}{R_E}$ is the potential energy of the mass M. 2) When the object reaches a height far away from Earth and hence treated as approaching infinity, the gravitational potential energy becomes zero [$U(\infty) = 0$] and the kinetic energy becomes zero as well. Therefore the final total energy of the object becomes zero. This is for minimum energy and for minimum speed to escape. Otherwise Kinetic energy can be non-zero. $E_f = 0$, According to the law of energy conservation, $E_i = E_f$ -------- 2 Substituting (1) in (2) we get, $\frac{1}{2} MV_i^2 - \frac{GMM_E}{R_E} = 0$ $\frac{1}{2} MV_i^2 = \frac{GMM_E}{R_E}$ ----------------- 3 3) The escape speed, the minimum speed required by an object to escape Earth's gravitational field, hence replace, V_i with V_e. i.e, $\frac{1}{2} MV_e^2 = \frac{GMM_E}{R_E}$ $V_e^2 = \frac{GMM_E}{R_E} \cdot \frac{2}{M}$; $V_e^2 = \frac{2GM_E}{R_E}$ ------------- 4 Using $g = \frac{GM_E}{R_e}$ ----------------- 5 $V_e^2 = 2gR_E$; $V_e = \sqrt{2gRE}$ -------------- 6 From equation (6) the escape speed depends on two factors: acceleration due to gravity and radius of the Earth. It is completely independent of the mass of the object.	2 1 1 1	5
	b) **Hydraulic lift** which is used to lift a heavy load with a small force. It is a force multiplier. It consists of two cylinders A and B connected to each other by a horizontal pipe, filled with a liquid. They are fitted with frictionless pistons of cross sectional areas A_1 and A_2 ($A_2 > A_1$). Suppose a downward force F is applied on the smaller piston, the pressure of the liquid under this piston increases to $P\left(\text{where, } P = \frac{F_1}{A_1}\right)$. But according to Pascal's law, this increased pressure P is transmitted undiminished in all directions. So a pressure is exerted on piston B. Upward force on piston B is $F_2 = PxA_2 = \frac{F_1}{A_1} x A_2 \Rightarrow F_2 = \frac{A_2}{A_1} x F_1$ Therefore by changing the force on the smaller piston A, the force on the piston B	1 2 1 1	5

has been increased by the factor $\frac{A_2}{A_1}$ and this factor is called the mechanical advantage of the lift

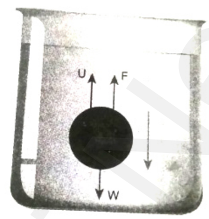
24

a) **Expression for terminal velocity:**

Consider a sphere of radius r which falls freely through a highly viscous liquid of coefficient of viscosity η. Let the density of the material of the sphere be ρ and the density of the fluid be σ. **1**

Gravitational force acting on the sphere, $F_G = mg = \frac{4}{3}\pi r^3 \rho g$ (downward force)

Up thrust, $U = \frac{4}{3}\pi r^3 \sigma g$ (upward force) **1**



Viscous force $F = 6\pi\eta r v_t$

At terminal velocity v_t, downward force = upward force

$F_G - U = F \Rightarrow \frac{4}{3}\pi r^3 \rho g - = \frac{4}{3}\pi r^3 \sigma g = 6\pi\eta r v_t$ **2**

$V_t = \frac{2}{9} x \frac{r^2(\rho-\sigma)}{\eta} g \Rightarrow V_t \propto r^2$

Here, it should be noted that the terminal speed of the sphere is directly proportional to the square of its radius. If σ is greater than ρ, then the term (ρ - σ) becomes negative leading to a negative terminal velocity. **1**

5

b) **Bernoulli's theorem :**

According to Bernoulli's theorem, the sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant. **1**

$\frac{P}{\rho} + \frac{1}{2}v^2 + gh =$ Constant, this is known as Bernoulli's equation.

Proof:

Let us consider a flow of liquid through a pipe AB as shown in Figure. Let V be the volume of the liquid when it enters A in a time t which is equal to the volume of the liquid leaving B in the same time. Let a_A, v_A and P_A be the area of cross section of the tube, velocity of the liquid and pressure exerted by the liquid at A respectively. **1**

Let the force exerted by the liquid at A is $F_A = P_A a_A$

Distance travelled by the liquid in time t is $d = v_A t$

Therefore, the work done is $W = F_A d = P_A a_A v_A t$

But $a_A v_A t = a_A d = V$, volume of the liquid entering at A.

Thus, the work done is the pressure energy (at A), $W = F_A d = P_A V$

Pressure energy per unit volume at A $= \frac{\text{Pressure energy}}{\text{Volume}} = \frac{P_A V}{V} = P_A$

	Pressure energy per unit mass at A = $\frac{\text{Pressure energy}}{\text{Mass}} = \frac{P_A V}{m} = \frac{P_A}{\frac{m}{V}} = \frac{P_A}{\rho}$ Since m is the mass of the liquid entering at A in a given time, therefore, pressure energy of the liquid at A is $E_{PA} = P_A V = P_A V \times \left(\frac{m}{m}\right) = m\frac{P_A}{\rho}$ Potential energy of the liquid at A, $P_{EA} = mg\,h_A$, Due to the flow of liquid, the kinetic energy of the liquid at A, $KE_A = \frac{1}{2} mV_A^2$ Therefore, the total energy due to the flow of liquid at A, $E_A = EP_A + KE_A + PE_A$ $E_A = m\frac{P_A}{\rho} + \frac{1}{2} mV_A^2 + mgh_A$ Similarly, let a_B, v_B, and P_B be the area of cross section of the tube, velocity of the liquid, and pressure exerted by the liquid at B. Calculating the total energy at E_B, we get $E_B = m\frac{P_B}{\rho} + \frac{1}{2} mV_B^2 + mgh_B$ From the law of conservation of energy, $E_A = E_B$ $E_A = m\frac{P_A}{\rho} + \frac{1}{2} mV_A^2 + mgh_A = E_B = m\frac{P_B}{\rho} + \frac{1}{2} mV_B^2 + mgh_B$ $\frac{P_A}{\rho} + \frac{1}{2} V_A^2 + gh_A = \frac{P_B}{\rho} + \frac{1}{2} V_B^2 + gh_B = \text{constant}$ Thus, the above equation can be written as $\frac{P}{\rho g} + \frac{1}{2}\frac{v^2}{g} + h = \text{constant}$	1 1 1	5

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