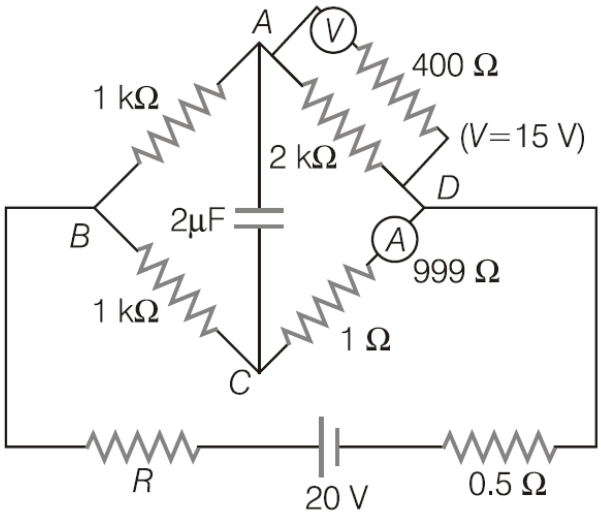
PART (A) : PHYSICS

SECTION-I : (SINGLE ANSWER CORRECT TYPE)

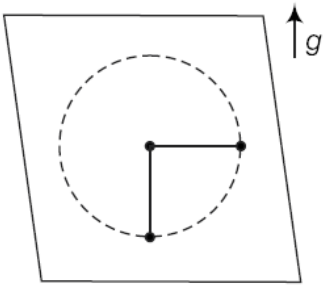
This section contains **08 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. Calculate the energy stored in the capacitor of capacitance 2μF. The voltmeter gives a reading of 15V and the ammeter *A* reads 15 mA.



(A) 5μJ (B) 10μJ (C) 0.5μJ (D) zero

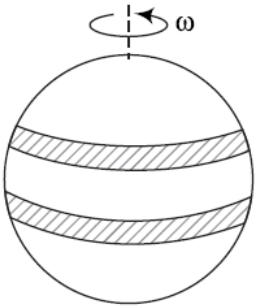
2. A cabin is moving upwards with constant acceleration equal to accelerate due to gravity *g*. A boy standing in the cabin wants to whirl a particle of mass *m* in a vertical circle of radius *r*.



The minimum velocity which should be provided at lowermost point (w.r.t. cabin) so, that particle can just complete the circle is (assume the string is ideal one)

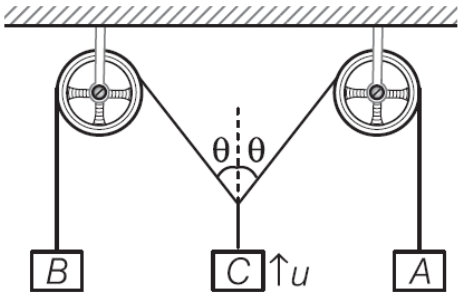
(A) $\sqrt{5gr}$ (B) $\sqrt{10\,gr}$ (C) $\sqrt{20\,gr}$ (D) $\sqrt{2\,gr}$

3. A player strikes a football such that it started spinning in the air with a angualr velocity ω as shown in the diagram. Another player of opposite team punchers the football through a sharp niddle in the air such that radius of the football contracts to 75% of its original value. What will be the new angular velocity of the football if weight of the football remains same



(A) $\frac{4}{7}\omega$ (B) $\frac{16}{9}\omega$ (C) $\frac{4}{25}\omega$ (D) $\frac{25}{4}\omega$

4. In the arrangement shown in the below figure, the two pulleys are fixed and the two blocks *A* and *B* are made to move downwards so that they decelerate at 10 ms^{-2}. The block *C*, which is fixed to the middle of the string moves upward with a constant velocity *u*. At a certain instant, θ (shown in the figure) = 30^o and $\left(\frac{d\theta}{dt}\right) = +1\,\text{rad}\,s^{-1}$. It can be concluded that *u* is equals to



(A) 5 ms^{-1} (B) 10 ms^{-1} (C) 20 ms^{-1} (D) 15 ms^{-1}

5. The equation of a vibrating string fixed at both ends, is given by

$$Y = (3\text{mm})\sin\left(\frac{\pi x}{15}\right)\sin(400\,\pi t)$$

where, *x* is the distance (in cm) measured from one end of the string, *t* is the time (in seconds) and *Y* gives the displacement. The string vibrates in 4 loops. The speed of transverse waves along the string for the fundamental node is equal to

(A) 60 ms^{-1} (B) 120 ms^{-1} (C) 30 ms^{-1} (D) 5.41 ms^{-1}

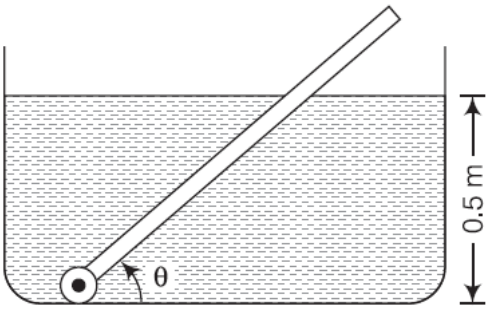
6. A planet of radius *R* has an acceleration due to gravity of g_s on its surface. A deep smooth tunnel is dug on this planet radially inward to reach a point *P*. *P* located at a distance of $\frac{R}{2}$ from the centre of the planet. Assume that the planet has uniform density. The kinetic energy required to be given to a small body of mass *m* projected radially outward from *P*, so that it gains a maximum altitude equal to thrice the radius of the planet from its surface is equal to

(A) $\frac{63}{16}mg_sR$ (B) $\frac{3}{8}mg_sR$ (C) $\frac{9}{8}mg_sR$ (D) $\frac{21}{16}mg_sR$

7. A light inextensible string is wrapped around a cylinder of mass *m* and radius *R*. The string is pulled vertically upward to prevent the centre of mass from falling as the cylinder unwinds the string. The length of the string unwound when the cylinder has reached a speed ω will be

(A) $\frac{R\omega}{4g}$ (B) $\frac{R^2\omega^2}{4g}$ (C) $\frac{R\omega}{8g}$ (D) $\frac{R^2\omega^2}{8g}$

8. A wooden plank of length 1 m and of uniform cross-section is hinged in a tank filled with water upto a height of 0.5 m as shown.



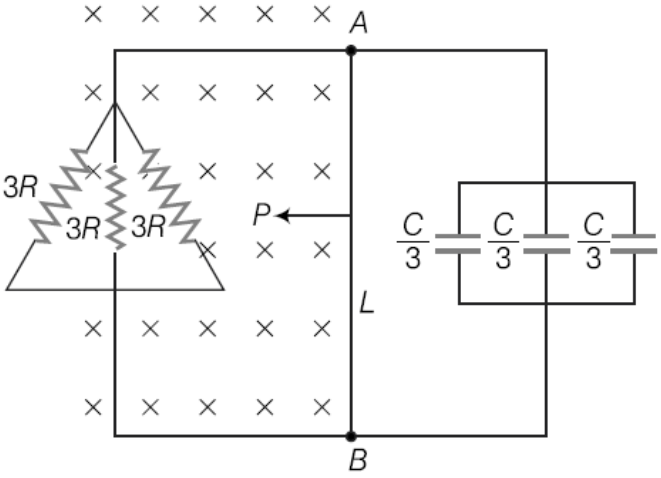
If specific gravity of the plank is 0.5, then angle θ which plank make with horizontal in equilibrium is

(A) $\frac{\pi}{4}$ (B) $\frac{2\pi}{3}$ (C) $\frac{\pi}{6}$ (D) $\frac{\pi}{3}$

SECTION-II : (MULTIPLE CORRECT ANSWER(S) TYPE)

This section contains **06 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE than one is/are correct.**

9. A conducting rod *AB* of length *L* is pulled with a constant force *P* towards left hand side. Resistance of each resistor is 3*R* and capacitance is *C*/3. The rod is moving along two parallel rails in region of constant magnetic field *B* as shown in the figure. Choose the correct statement(s).



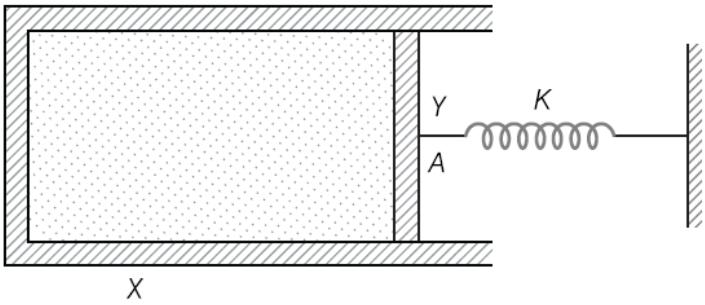
(A) maximum charge on the combination of capacitor is $q_{max} = \frac{2PRC}{BL}$

(B) terminal velocity of the rod is $\frac{2PR}{B^2L^2}$

(C) terminal velocity of the rod is $\frac{PR}{B^2L^2}$

(D) maximum charge on the combination of capacitors is $\frac{PRC}{BL}$

10. Consider a long cylindrical container *X* as shown in the diagram. The container contains a gas of density ρ with molecules of mass *m*. All the walls are frictionless. Temperature of the gas is *T* and the piston *Y* remains in equilibrium as shown in the diagram then



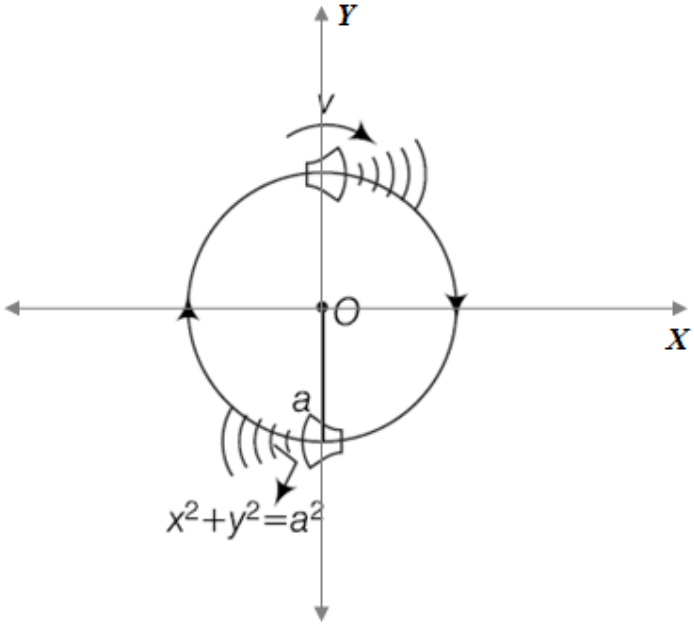
(A) Pressure of the gas is $\frac{\rho K_B T}{m}$

(B) Potential energy stored in the spring is $\frac{\rho^2 K_B^2 T^2 K}{2m^2 A^2}$

(C) Pressure of the gas is $\frac{\rho K_B T}{2mA}$

(D) Compression is the spring is $\frac{pK_B T}{2mA}$

11. A sound source is moving along a circular path of radius *a* with constant speed of $\upsilon = \frac{320\pi}{3\sqrt{3}} \text{ms}^{-1}$ in clockwise direction as shown in the figure. an observer is at rest at a point located at (2*a*, 0) w.r.t. centre of the circle. Assuming that the frequency of sound emitted by the source is ν_0 and speed of sound in the air as $\upsilon_S = 320\,\text{ms}^{-1}$. Which of the following is / are correct?



(A) maximum frequency heard by the observer is $\frac{3\sqrt{3}}{3\sqrt{3}-\pi}\nu_0$

(B) minimum frequency heard by the observer is $\frac{3\sqrt{3}}{3\sqrt{3}+\pi}\nu_0$

(C) position of the source when observer receive maximum frequency is $\left(\frac{a}{2}, \frac{\sqrt{3}a}{2}\right)$

(D) position of the source when observer receives minimum frequency is $\left(-\frac{a}{2}, \frac{\sqrt{3}a}{2}\right)$

12. The smallest division on main scale of a vernier calipers is 1 mm and 10 vernier divisions coincide with 9 main scale divisions. While measuring length of a line the zero mark of the vernier scale lies between 10.2 cm and 10.3 cm and the third division of the vernier scale coincide with the main scale division then

(A) least count of calipers is 0.1 mm (B) length of the line is 10.23 cm
(C) least count of calipers is 0.2 mm (D) length of the line is 10.15 cm

13. A thin paper of thickness 0.02 mm having reafractive index 1.45 is pasted across one of the slits in a Young's double slit experiment. The paper transmits $\frac{4}{9}$ of light falling on it. (λ_{light} = 600 nm)

(A) Amplitude of light wave tranmitted through the paper will be 2/3 times of incident wave.
(B) The ratio of maximum and minimum intensity in the fringe pattern will be 25.
(C) The total number of fringe crossing the centre if an indentical paper is pasted on the other slit is 15.
(D) The ratio of maximum and minimum intensity in the pattern will be 5.

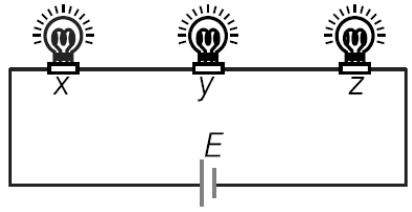
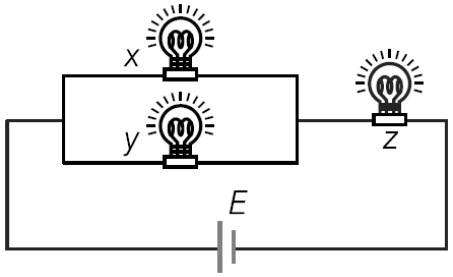
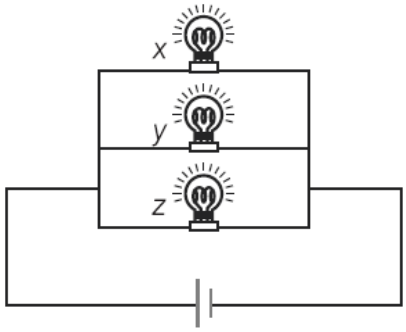
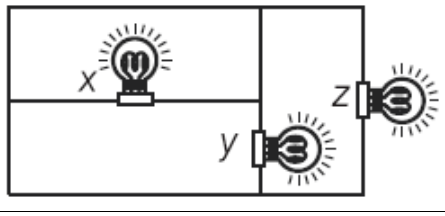
14. When a current-carrying coil is placed in a uniform magnetic field with its magnetic moment anti-parallel to the field.

(A) Torque on it is maximum (B) Torque on it is zero
(C) Potential enerngy is maximum (D) Coil is in unstable equilibrium

SECTION-III : (MATRIX-MATCH TYPE)

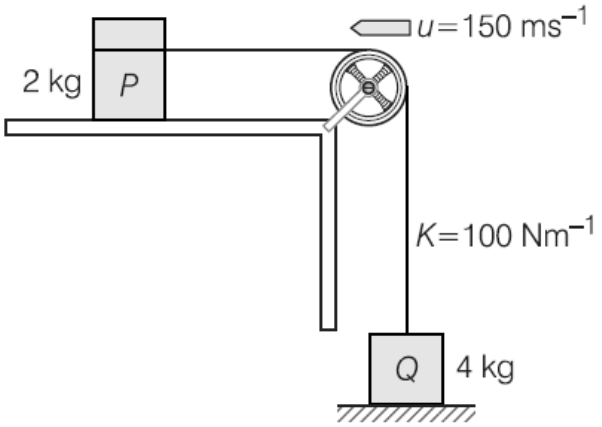
This section contains **02 Matrix Match**. Each question has matching lists. Each question has four choice (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

15. Three bulbs *X*, *Y* and *Z* are rated as $(p_X, V), (p_Y, V)$ and (p_Z, V) respectively. It is given that $p_X > p_Y > p_Z$. Column I indicates the arrangement of the bulbs in different configurations. Column II gives corresponding brightness neglecting the variation in resistance due to change in temperature match the Column I with Column II.

Column I		Column II	
P.		**1.**	*Z* is glowing with maximum brightness.
Q.		**2.**	*X* is having the minimum brightness.
R.		**3.**	*Y* is glowing with minimum brightness.
S.		**4.**	*X* is glowing with maximum brightness.

(A) (P) → 1, 4; (Q) → 1, 2; (R) → 2; (S) → 3
(B) (P) → 1, 3; (Q) → 1, 4; (R) → 4; (S) → 2
(C) (P) → 1, 2; (Q) → 1, 3; (R) → 2; (S) → 2
(D) (P) → 1, 2; (Q) → 2, 3; (R) → 3; (S) → 4

16. A block *P* of mass M_P = 2 kg is kept on a smooth horizontal surface and attached by a light thread to another block *Q* of mass M_Q = 4 kg. Block *Q* is resting on ground and thread and pulley are massless and frictionless. A bullet of mass *m* is 0.25 kg is moving horizontally with velocity *u* = 1250 ms^{-1} penetrates through block *P* and emerges out with velocity of 90 ms^{-1}.



Column I		Column II	
P.	Velocity of the block Q just after the bullet comes out (in m/s).	**1.**	15
Q.	Maximum displacement of the block P in left direction (in m).	**2.**	10
R.	Impulse imported by the string on block Q (in N-s).	**3.**	$\frac{47}{100}$
S.	Impulse imported by the bullet on block P (in N-s).	**4.**	$\frac{5}{2}$

(A) (P) $\rightarrow$ 1, (Q) $\rightarrow$ 3, (R) $\rightarrow$ 2, (S) $\rightarrow$ 4 (B) (P) $\rightarrow$ 4, (Q) $\rightarrow$ 3, (R) $\rightarrow$ 2, (S) $\rightarrow$ 1

(C) (P) $\rightarrow$ 1, (Q) $\rightarrow$ 2, (R) $\rightarrow$ 3, (S) $\rightarrow$ 4 (D) (P) $\rightarrow$ 3, (Q) $\rightarrow$ 4, (R) $\rightarrow$ 1, (S) $\rightarrow$ 2

SECTION-IV : (INTEGER ANSWER TYPE)

This section contains **04** questions. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, 0.33, 30.27, 127.30)

17. A galvanometer gives full scale deflection with 0.006 A current. By connecting it to a 4990 Ω resistance, it can be converted into a voltmeter of range 0-30 V. If connected to a $\frac{2n}{249}\Omega$ resistance, it becomes an ammeter of range 0-1.5 A. The value of n is

18. A massless string of length L is fixed at one end and connected to a bob of mass m at the other end. The string makes ω/π revolutions per second around the vertical axis through the fixed end. If tension in the string is 64 mL, then ω is

19. The inductor in a L-C oscilation has a maximum potential differnece of 32 V and maximum enerngy of 1280 μJ. The value of capacitance for the L-C circuit is μF in $\frac{n}{2}$, Evaluate n.

20. A uniform ring of mass m and radius $a = \frac{80}{23\pi^2}$ is pivoted smoothly at O. If a uniform disc of mass m and radius a is welded at the periphery of the ring, then find the time period of SHM of the system (ring + disc) (in seconds)