# PART (A) : PHYSICS

## SECTION-I : (SINGLE ANSWER CORRECT TYPE)

This section contains **04 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. The figure shown gives values of R_1 and R_2, the balance point for jockey is at 30 cm from A. When R_2 is shunted by a resistance of 10Ω, jockey has to slide 20 cm to obtain balance point. The values of R_1 and R_2 are
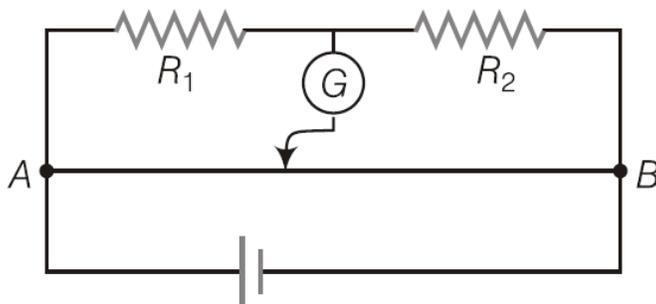
    (A) $\frac{10}{5}\Omega, 5\Omega$ (B) $\frac{40}{3}\Omega, \frac{40}{7}\Omega$ (C) $\frac{40}{7}\Omega, \frac{40}{3}\Omega$ (D) None of these
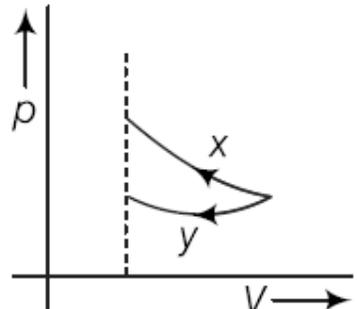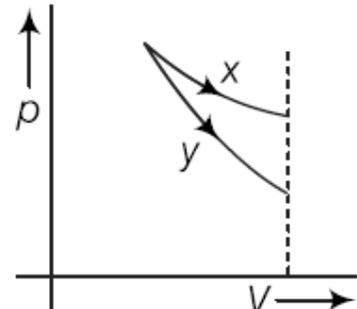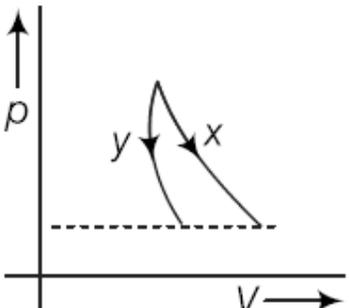
2. During measurement of the refractive index of a transparent slab (L) using travelling microscope of the real depth at the bottom is 7 cm. Reading of the cross due to refraction is found as 8 cm. Also reading at the top of the slab is 10 cm. refractive index of material of the slab is
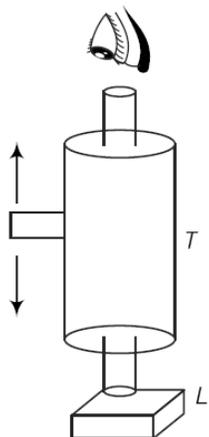
   (A) 1.5   (B) 1.6   (C) 1.4   (D) 1.3

3. An ideal gas undergoes two processes X and Y. One of these is adiabatic and the other is isothermal. Corresponding to p-V graphs in Column I match the quantities given in Column II.

Column I	Column II
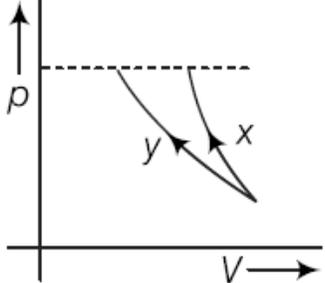
P.		**1.**	Heat supplied during curve X is positive.
Q.		**2.**	Work done by the gas in both processes is positive.
R.		**3.**	Temperature of gas in process Y is constant.
S.		**4.**	Internal energy increases in adiabatic process.

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

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

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

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

4. A charge q exists at a distance of R from a spherical concave mirror of radius of curvature R. Let mirror subtends a half angle $\theta = 30^\circ$ at the charge.
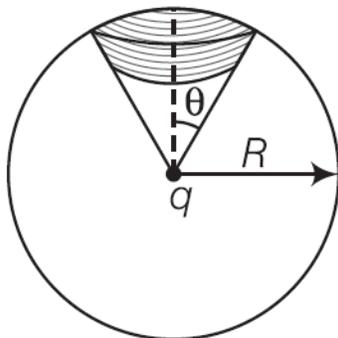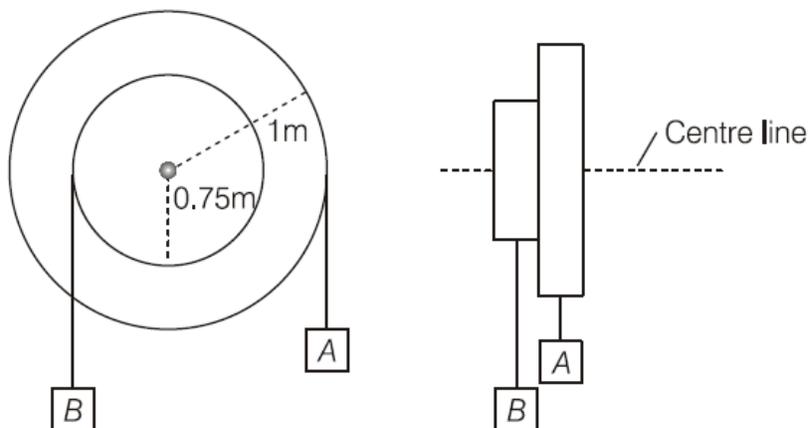
Flux passing through the mirror is

(A) $\dfrac{q\sin^2 15^\circ}{\varepsilon_0}$ (B) $\dfrac{q\sin^2 30^\circ}{\varepsilon_0}$ (C) $\dfrac{q\sin^2 30^\circ}{2\varepsilon_0}$ (D) $\dfrac{q\sin^2 15^\circ}{2\varepsilon_0}$

SECTION-II : (COMPREHENSIONS TYPE)

This section contains **06** questions. Based on each paragraph, there are **TWO** questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out which **ONLY ONE** is correct.

PARAGRAPH FOR QUESTIONS NO. 5 & 6

The step pulley shown, starts from rest and accelerates at 2 rad s^{-2}.

5. What time t is required for block A to move 20 m?
(A) 4.47 s (B) 3.47 s (C) 5.47 s (D) 6.47 s

6. The velocity of A at time t (mentioned in the above question) (in ms^{-1}) is
(A) 9.94 (B) 8.94 (C) 7.94 (D) 6.94

PARAGRAPH FOR QUESTIONS NO. 7 & 8

Monochromatic light of wavelength λ is 5500Å is incident on the slits of a Young's double slit experiment (*YDSE*) as shown in the figure.
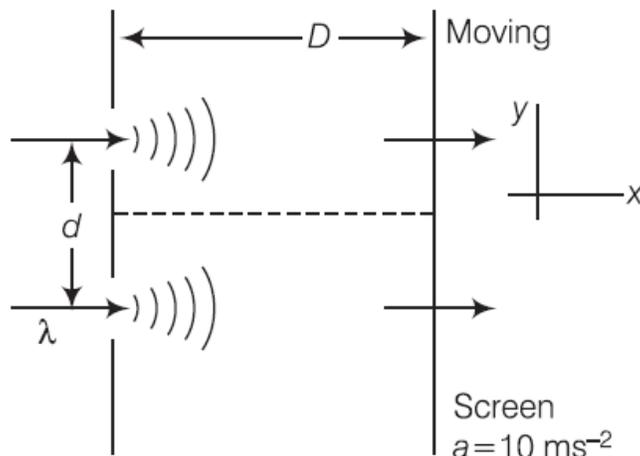
The screen is moving towards right with an acceleration a of 10 ms^{-2}. It is given that d is 2 mm and D is 2 m.

7. Velocity (in ms^{-1}) of central maxima of *YDSE* discussed in the above passage at $t = 4\text{s}$ is

(A) $10\hat{\mathbf{i}}$ (B) $-20\hat{\mathbf{i}}$ (C) $-40\hat{\mathbf{j}}$ (D) $40\hat{\mathbf{i}}$

8. Velocity (in cm(s)) of 2nd minima with respect to central maxima at $t = 4\text{s}$ is

(A) $265\hat{\mathbf{j}}$ (B) $1.65\hat{\mathbf{j}}$ (C) $1.5\hat{\mathbf{i}}$ (D) $-1.65\hat{\mathbf{j}}$

PARAGRAPH FOR QUESTIONS NO. 9 & 10

The nuclear reaction $n + {}^{10}_{5}B \longrightarrow {}^{7}_{3}\text{Li} + {}^{4}_{2}\text{He}$ is observed to occur even when very slow moving neutrons $(m_n = 1.0087\,\text{u})$ strike a boron atom at rest. For a particular reaction in which $K_n \approx 0$, the helium $(m\text{He} = 4.0026\,\text{u})$ is observed to have a speed of $9.30 \times 10^6\,\text{ms}^{-1}$. Evaluate

9. The kinatic enerngy of the lithium (mLi = 7.0160 u)

(A) 1.02 MeV   (B) 2.04 MeV   (C) 0.04 MeV   (D) 3.06 MeV

10. The *Q*-value of the reaction

(A) 1.82 MeV   (B) 2.82 MeV   (C) 4.16 MeV   (D) 0.82 MeV

## SECTION-III : (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.**

11. If nuclei of a radioactive element X are being produced at a constant rate δ and the element has a decay constant η then (assume that N_0 nuclei of the element were present at $t = 0$ and $\delta = 3\eta N_0$)

(A) number of nuclei of X after two half-lives is $2.5N_0$
(B) number of nuclei of X after very long time is $3N_0$
(C) number of nuclei of X after two half lives is $1.5N_0$
(D) number of nuclei of X after very long time is N_0

12. An object O is placed on the principal axis of a combinaton of mirror M and a slab L. If image of the object O coincides with it thus,
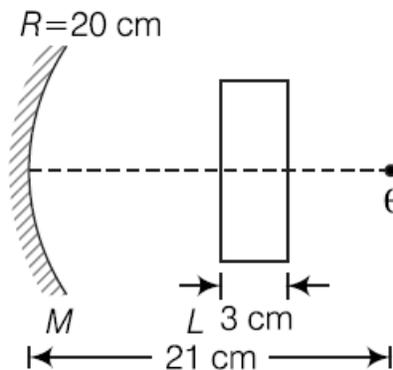
(A) refractive index of the material of the slab is 3/2
(B) shift introduced due to the slab is 1 cm
(C) shift introduced due to the slab is 2 cm
(D) refractive index of the material of the slab is 5/3

13. A copper cylinder of mass 1 kg is heated electrically by a 15 W heater in a room at 20ºC. Temperature of the cylinder increases uniformly to 30ºC in 5 min and finally becomes constant at 50ºC. Assume that the rate of loss of heat is directly proportional to the excess temperature over the surroundings then
(A) the rate of loss of heat of the cylinder to the surrounding at 50ºC is 15 W.
(B) the rate of loss of heat of the cylinder to surrounding at 30ºC is 5 W.
(C) the rate of loss of heat of the cylinder to the surrounding at 50ºC is 5 W.
(D) the rate of loss of heat of the cylinder to surrounding at 30ºC is 15 W.

14. A particle of mass m and magnitude of charge q is dropped along the axis of a non-conducting disc of radius a and positive surface charge density σ as shown in the diagram. If gravity is neglected then
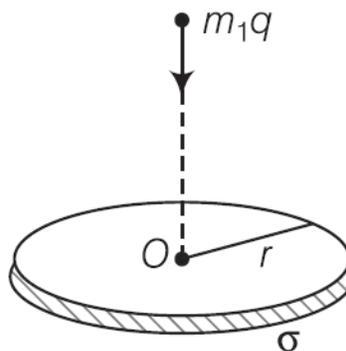
(A) Electric potential at the centre of the disc is $\dfrac{\sigma a}{2\varepsilon_0}$

(B) Electric potential at the centre of the disc is $\dfrac{\sigma a}{\varepsilon_0}$

(C) KE of the particle at the centre as $h \to a$ is $q\left[\dfrac{\sigma}{2\varepsilon_0}\left\{\sqrt{2}a - 2a\right\}\right]$

(D) KE of the particle at the centre as $h \rightarrow a$ is $q\left[\dfrac{\sigma}{2\varepsilon_0}\left\{\sqrt{2}a+2a\right\}\right]$

15. The molar heat capacity for an ideal gas
   (A) is zero for an adiabatic process
   (B) is infinite for an isothermal process
   (C) depends only on the nature of the gas and thermodynamic process.
   (D) is equal to the product of the molecular weight and specific heat capacity for any process.

16. From the following equations pick out the possible nuclear fusion reactions
   (A) $_6C^{13} + {_1}H^1 \rightarrow {_6}C^{14} + 1.3$ MeV
   (B) $_6C^{12} + {_1}H^1 \rightarrow {_7}N^{14} + 2$ MeV
   (C) $_7N^{14} + {_1}H^1 \rightarrow {_8}O^{15} + 7.3$ MeV
   (D) $_{92}U^{235} + {_0}n^1 \rightarrow {_{54}}Xe^{140} + 36\ Sr^{94} + {_0}n^1 + {_0}n^1 + Y + 200$ MeV

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. An electron is in nth excited state of Be^{3+} ion. The de-Broglie wavelength of the electron in this state is $4\pi a_0$ (where a_0 is the Bohr radius). The value of n is

18. Nitrogen molecules are enclosed in a vessel as shown in the diagram. When the spark key P is pressed it raised the temperature of the gas three times and nitrogen molecules dissociate into atoms. If rms speed of the molecules before sparking was υ then after sparking it becomes $\sqrt{n}\upsilon$. Find the valuef of n.
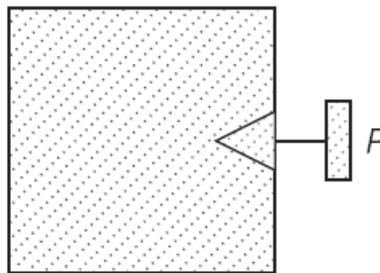
19. In a large cylindrical water tank there are two small holes ϕ_1 and ϕ_2 on the wall at a depth of Y_1 from upper level of water and at a height Y_2 from the lower end of the tank respectively as shown in the figure. water coming out from both the holes strike the ground at the same point. compute the ratio of Y_1 and Y_2.
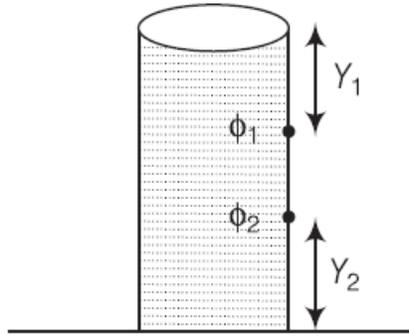
20. A cannon ball is imparted an initial velocity of 30 ms^{-1} at an angle of 53° to the horizontal. After some time the ball is seen to travel at an angle of 37° below horizotnal. Compute the time consumed (in second) till then, upto nearest integer.