

PART I
SECTION - I

Straight Objective Type

This section contains 9 multiple choice questions numbered 1 to 9. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

1. In the experiment to determine the speed of sound using a resonance column,
 - (A) prongs of the tuning fork are kept in a vertical plane
 - (B) prongs of the tuning fork are kept in a horizontal plane
 - (C) in one of the two resonances observed, the length of the resonating air column is close to the wavelength of sound in air
 - (D) in one of the two resonances observed, the length of the resonating air column is close to half of the wavelength of sound in air

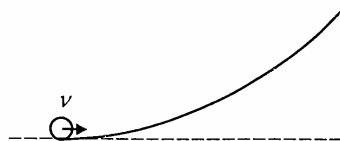
2. A student performs an experiment to determine the Young's modulus of a wire, exactly 2 m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ± 0.05 mm at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take $g = 9.8 \text{ m/s}^2$ (exact). The Young's modulus obtained from the reading is

(A) $(2.0 \pm 0.3) \times 10^{11} \text{ N/m}^2$	(B) $(2.0 \pm 0.2) \times 10^{11} \text{ N/m}^2$
(C) $(2.0 \pm 0.1) \times 10^{11} \text{ N/m}^2$	(D) $(2.0 \pm 0.05) \times 10^{11} \text{ N/m}^2$

3. A particle moves in the X-Y plane under the influence of a force such that its linear momentum is $\vec{p}(t) = A[\hat{i} \cos(kt) - \hat{j} \sin(kt)]$, where A and k are constants. The angle between the force and the momentum is

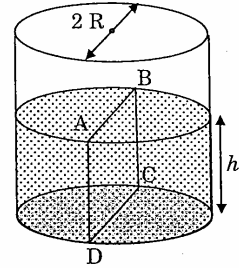
(A) 0°	(B) 30°	(C) 45°	(D) 90°
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4. A small object of uniform density rolls up a curved surface with an initial velocity v . It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is

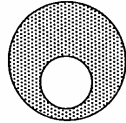


- | | | | |
|----------|------------------|-------------------|----------|
| (A) ring | (B) solid sphere | (C) hollow sphere | (D) disc |
|----------|------------------|-------------------|----------|

5. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ , the surface tension of water is T and the atmospheric pressure is P_0 . Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude



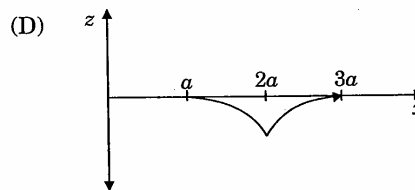
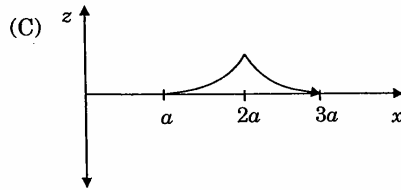
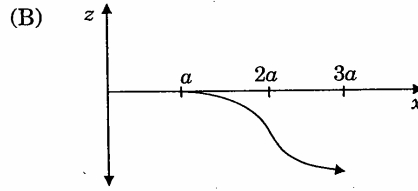
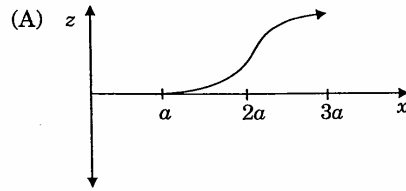
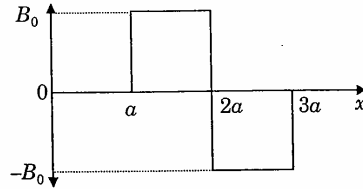
- (A) $|2P_0 R h + \pi R^2 \rho g h - 2RT|$ (B) $|2P_0 R h + R \rho g h^2 - 2RT|$
 (C) $|P_0 \pi R^2 + R \rho g h^2 - 2RT|$ (D) $|P_0 \pi R^2 + R \rho g h^2 + 2RT|$
6. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume as shown in the figure. The electric field inside the emptied space is



- (A) zero everywhere (B) non-zero and uniform
 (C) non-uniform (D) zero only at its center
7. Positive and negative point charges of equal magnitude are kept at $(0, 0, \frac{a}{2})$ and $(0, 0, \frac{-a}{2})$, respectively. The work done by the electric field when another positive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is
- (A) positive
 (B) negative
 (C) zero
 (D) depends on the path connecting the initial and final positions

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8. A magnetic field $\vec{B} = B_0 \hat{j}$ exists in the region $a < x < 2a$ and $\vec{B} = -B_0 \hat{j}$, in the region $2a < x < 3a$, where B_0 is a positive constant. A positive point charge moving with a velocity $\vec{v} = v_0 \hat{i}$, where v_0 is a positive constant, enters the magnetic field at $x = a$. The trajectory of the charge in this region can be like,



9. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is

(A) $\lambda_0 = \frac{2mc\lambda^2}{h}$

(B) $\lambda_0 = \frac{2h}{mc}$

(C) $\lambda_0 = \frac{2m^2 c^2 \lambda^3}{h^2}$

(D) $\lambda_0 = \lambda$

SECTION - II

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Assertion - Reason Type

This section contains 4 questions numbered 10 to 13. Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

10. STATEMENT-1

If there is no external torque on a body about its center of mass, then the velocity of the center of mass remains constant.

because

STATEMENT-2

The linear momentum of an isolated system remains constant.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True

11. STATEMENT-1

A cloth covers a table. Some dishes are kept on it. The cloth can be pulled out without dislodging the dishes from the table.

because

STATEMENT-2

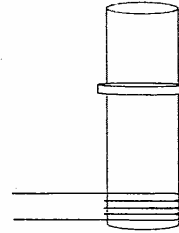
For every action there is an equal and opposite reaction.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True

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12. STATEMENT-1

A vertical iron rod has a coil of wire wound over it at the bottom end. An alternating current flows in the coil. The rod goes through a conducting ring as shown in the figure. The ring can float at a certain height above the coil.



because

STATEMENT-2

In the above situation, a current is induced in the ring which interacts with the horizontal component of the magnetic field to produce an average force in the upward direction.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True

13. STATEMENT-1

The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

because

STATEMENT-2

The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (B) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
- (C) Statement-1 is True, Statement-2 is False
- (D) Statement-1 is False, Statement-2 is True

SECTION - III

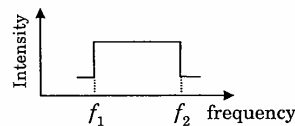
Linked Comprehension Type

This section contains 2 paragraphs P₁₄₋₁₆ and P₁₇₋₁₉. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

P₁₄₋₁₆ : Paragraph for Question Nos. 14 to 16

Two trains A and B are moving with speeds 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle.

Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800$ Hz to $f_2 = 1120$ Hz, as shown in the figure. The spread in the frequency (highest frequency – lowest frequency) is thus 320 Hz. The speed of sound in still air is 340 m/s.



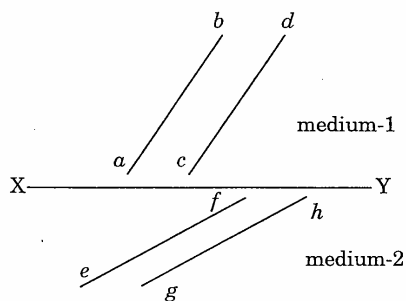
14. The speed of sound of the whistle is
 (A) 340 m/s for passengers in A and 310 m/s for passengers in B
 (B) 360 m/s for passengers in A and 310 m/s for passengers in B
 (C) 310 m/s for passengers in A and 360 m/s for passengers in B
 (D) 340 m/s for passengers in both the trains
15. The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by
- (A)

(B)
- (C)

(D)
16. The spread of frequency as observed by the passengers in train B is
 (A) 310 Hz (B) 330 Hz (C) 350 Hz (D) 290 Hz

P17-19: Paragraph for Question Nos. 17 to 19

The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave traveling in medium-1 and incident on XY . The lines ef and gh represent wavefronts of the light wave in medium-2 after refraction.



17. Light travels as a
- (A) parallel beam in each medium
 - (B) convergent beam in each medium
 - (C) divergent beam in each medium
 - (D) divergent beam in one medium and convergent beam in the other medium
18. The phases of the light wave at c , d , e and f are ϕ_c , ϕ_d , ϕ_e and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$.
- (A) ϕ_c cannot be equal to ϕ_d
 - (B) ϕ_d can be equal to ϕ_e
 - (C) $(\phi_d - \phi_f)$ is equal to $(\phi_c - \phi_e)$
 - (D) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$
19. Speed of light is
- (A) the same in medium-1 and medium-2
 - (B) larger in medium-1 than in medium-2
 - (C) larger in medium-2 than in medium-1
 - (D) different at b and d

SECTION - IV

Matrix-Match Type

This section contains 3 questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column I** have to be matched with statements (p, q, r, s) in **Column II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.

If the correct matches are A-p, A-s, B-q, B-r, C-p, C-q and D-s, then the correctly bubbled 4×4 matrix should be as follows :

	p	q	r	s
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

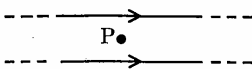
20. **Column I** describes some situations in which a small object moves. **Column II** describes some characteristics of these motions. Match the situations in **Column I** with the characteristics in **Column II** and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

- | Column I | Column II |
|--|--|
| <p>(A) The object moves on the x-axis under a conservative force in such a way that its “speed” and “position” satisfy $v = c_1 \sqrt{c_2 - x^2}$, where c_1 and c_2 are positive constants.</p> | <p>(p) The object executes a simple harmonic motion.</p> |
| <p>(B) The object moves on the x-axis in such a way that its velocity and its displacement from the origin satisfy $v = -kx$, where k is a positive constant.</p> | <p>(q) The object does not change its direction.</p> |
| <p>(C) The object is attached to one end of a mass-less spring of a given spring constant. The other end of the spring is attached to the ceiling of an elevator. Initially everything is at rest. The elevator starts going upwards with a constant acceleration a. The motion of the object is observed from the elevator during the period it maintains this acceleration.</p> | <p>(r) The kinetic energy of the object keeps on decreasing.</p> |
| <p>(D) The object is projected from the earth’s surface vertically upwards with a speed $2\sqrt{GM_e/R_e}$, where, M_e is the mass of the earth and R_e is the radius of the earth. Neglect forces from objects other than the earth.</p> | <p>(s) The object can change its direction only once.</p> |

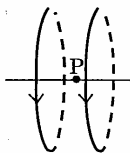
21. Two wires each carrying a steady current I are shown in four configurations in **Column I**. Some of the resulting effects are described in **Column II**. Match the statements in **Column I** with the statements in **Column II** and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

Column I

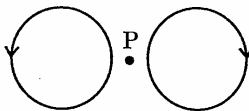
(A) Point P is situated midway between the wires.



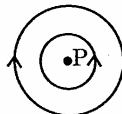
(B) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii.



(C) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii.



(D) Point P is situated at the common center of the wires.



Column II

(p) The magnetic fields (B) at P due to the currents in the wires are in the same direction.

(q) The magnetic fields (B) at P due to the currents in the wires are in opposite directions.

(r) There is no magnetic field at P.

(s) The wires repel each other.

22. **Column I** gives some devices and **Column II** gives some processes on which the functioning of these devices depend. Match the devices in **Column I** with the processes in **Column II** and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

Column I

- (A) Bimetallic strip
- (B) Steam engine
- (C) Incandescent lamp
- (D) Electric fuse

Column II

- (p) Radiation from a hot body
- (q) Energy conversion
- (r) Melting
- (s) Thermal expansion of solids