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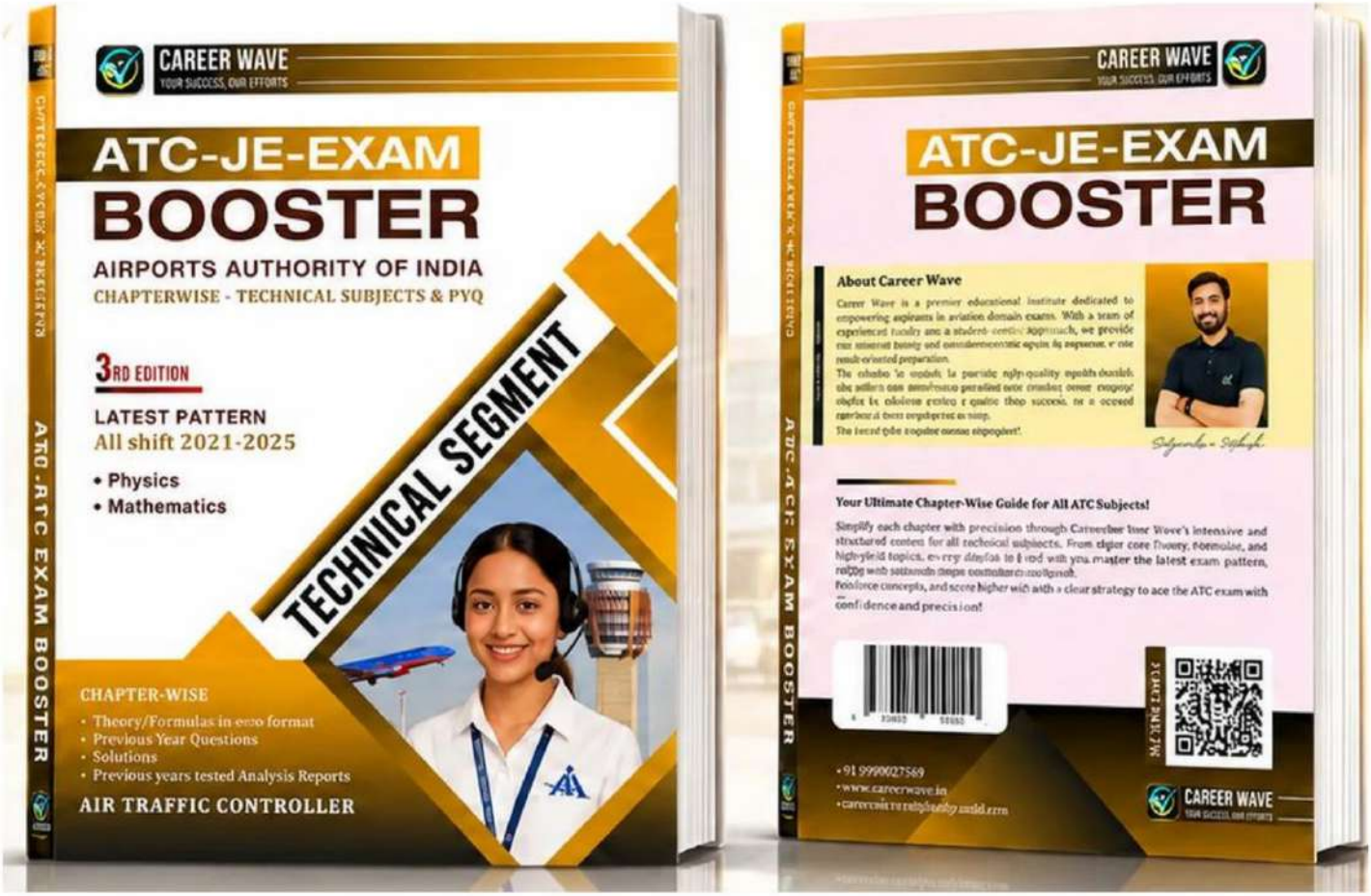


Physics – Laws of Motion: chapter insights, essential concepts and theory, previous year questions, 20 practice questions, answer key and solutions

Mathematics – Sets: theory, previous year questions, answer key and solutions

By Satyendraa Sir · Career Wave

Laws of Motion

Concept in 30 seconds: Net force changes momentum, F = dp/dt; action and reaction act on different bodies, so they never cancel. AAI trap: friction on a resting body equals the push, not μN, and rpm or km/h must be converted first.

What AAI Asks from This Chapter — 27 PYQs (2021–2025)

Key: ★ most asked in AAI-JE (ATC) (2021–2025)

- **Friction + circular motion = 13 of 27 (48%)** — study sections 06 and 09 first.
- Friction was asked in **all three** papers (2021, 2023, 2025). 2023 shifted towards **momentum** and **Newton's laws**.
- About half are **one-step** (13 one-step, 14 two-step); unit conversion (km/h, rpm) decides many of them.
- Topics are from NCERT Class XI Ch 4 (collisions: Ch 5).

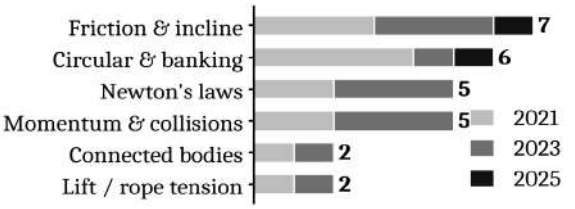


Fig. 4.1 PYQs by topic and year

01) Inertia and Newton's First Law

Galileo: on a frictionless surface a moving body keeps moving — force is needed only to change motion (Aristotle wrongly thought force keeps it moving).

First law: no net force ⇒ rest or uniform straight-line motion. This property is **inertia**; mass measures it. Inertia is of three kinds: rest, motion and direction.

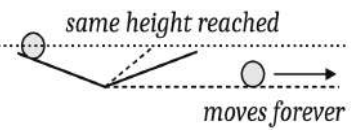


Fig. 4.2 Galileo's double incline

02) Momentum, Second Law and Impulse ★

$\vec{p} = m\vec{v}$; $\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}$; impulse $\vec{J} = \Delta\vec{p}$ = net (signed) area under the F–t graph (equal to $\vec{F}\Delta t$ for constant F). $F = ma$ holds for constant mass. In an oblique rebound only the normal component of velocity reverses.

Situation	*Result*	*Situation*	*Result*
Rebound with the same speed v	$\lvert\Delta p\rvert = 2mv$	Water jet rebounds with same speed	$F = 2\rho Av^2$
Stopped, no rebound	$\lvert\Delta p\rvert = mv$	Hands pulled back while catching	larger Δt ⇒ smaller F
Water jet stopped by a wall	$F = \rho Av^2$	Oblique rebound, θ from the normal	$\lvert\Delta p\rvert = 2mv\cos\theta$

Illustration: A 0.15 kg ball at 20 m/s is caught and stopped in 0.1 s: $F = 0.15 \times 20/0.1 = 30$ N. Pulling the hands back so it stops in 0.3 s cuts this to 10 N.

Units: Weight $W = mg$ is a force (N); mass (kg) does not change from place to place.

03) Newton's Third Law and Conservation of Momentum ★

Third law: action and reaction are equal, opposite, simultaneous and act on **different bodies** — they never cancel. (mg and N on one block are not a pair.)

Conservation : zero net external force ⇒ $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$.

Recoil from rest: $V = -\frac{m}{M}v$ (gun M, bullet m).

Also asked: a body at rest that breaks up keeps $\sum\vec{p} = 0$; rocket at lift-off: thrust $- mg = ma$, so thrust is $m(g + a)$.

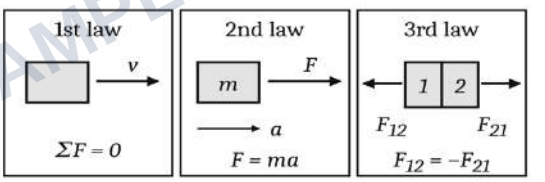


Fig. 4.3 Newton's three laws

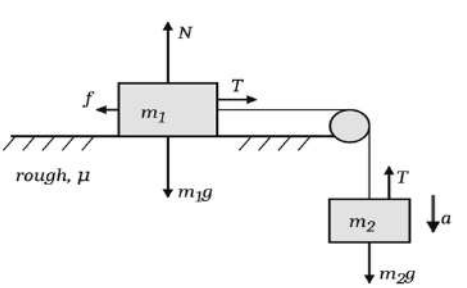
04) Equilibrium and Free-Body Diagrams ★

Strings at a knot: resolve the tensions, $\sum F_x = 0$ and $\sum F_y = 0$. Strings from the same level: the one closer to vertical carries more tension.

Equilibrium: $\sum\vec{F} = 0$ — the body is at rest or moves with constant velocity ($F = f$, $N = mg$ on a level floor).

Net force from an FBD: draw each body alone, mark every force, choose axes along a and write $\sum F = ma$.

Block m_1 on a rough table, pulled by a hanging m_2: $T - \mu m_1 g = m_1 a$ and $m_2 g - T = m_2 a$ (the same string tension T on both).



Block on a rough table pulled by a hanging mass

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05) Connected Bodies and Pulleys ★

Smooth floor: $a = \frac{F}{\sum m}$*; tension in a string = (total mass beyond it, away from the pull) × a. Take strings light and inextensible, pulleys frictionless.*

System	Acceleration	Tension
Atwood machine ($m_1 > m_2$)	$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$	$T = \frac{2m_1 m_2 g}{m_1 + m_2}$
m_1 *on smooth incline,* m_2 *hanging,* $m_2 > m_1 \sin\theta$	$a = \frac{(m_2 - m_1 \sin\theta)g}{m_1 + m_2}$	$T = m_2(g - a)$
m_1 *on rough table,* m_2 *hanging,* $m_2 > \mu m_1$	$a = \frac{(m_2 - \mu m_1)g}{m_1 + m_2}$	$T = m_2(g - a)$

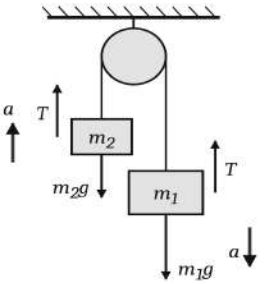

Fig. 4.5 Atwood machine

06) Friction ★

Static friction self-adjusts: $f_s = F$ until $f_{s,\max} = \mu_s N$. **Kinetic** $f_k = \mu_k N$ while sliding ($\mu_k < \mu_s$); **rolling friction** is the least. Independent of contact area.

Angle of repose θ_r: $\tan\theta_r = \mu_s$ (steepest slope where a block stays at rest).

Box on a truck: stays with it if $a \le \mu_s g$; beyond that it slips back with relative acceleration $a - \mu_k g$.

Blocks *A* and *B* pushed together against a wall: floor friction acts on the whole $A + B$ system, $f = \mu(m_A + m_B)g$, so the wall takes $F - f$.

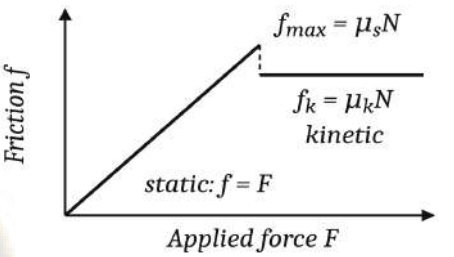

Fig. 4.6 Friction vs applied force

> **Illustration:** A 4 kg block ($g = 10$ m/s^2) rests on a floor ($\mu_s = 0.5$, $\mu_k = 0.4$). Push 15 N: $f_{\max} = 20$ N, so it stays and $f = 15$ N. Push 25 N: it slides, $f = \mu_k mg = 16$ N, $a = \frac{25 - 16}{4} = 2.25$ m/s^2.

07) Motion on an Incline

Case	*Result*
Smooth	$a = g\sin\theta$
Rough, sliding down ($\tan\theta > \mu_s$)	$a = g(\sin\theta - \mu_k \cos\theta)$
Moving up the slope (retardation)	$a = g(\sin\theta + \mu_k \cos\theta)$
Stays at rest	$\tan\theta \le \mu_s$, $f = mg\sin\theta$
Normal force	$N = mg\cos\theta$

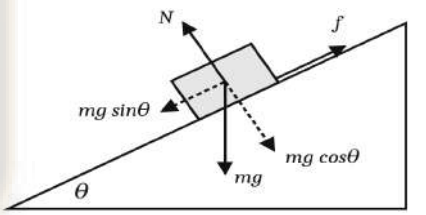

Fig. 4.7 Forces on an incline

Projected **up** a rough incline, gravity and friction both act down the slope: it stops after $s = \frac{u^2}{2g(\sin\theta + \mu_k \cos\theta)}$.

08) Apparent Weight in a Lift ★

A scale reads the normal force N, not mg. Reading in kg: N/g.

Acceleration **up**: $N = m(g + a)$;

acceleration **down**: $N = m(g - a)$;

free fall: $N = 0$. (Direction of a, not of motion.)

In the lift's frame add a pseudo force ma opposite to a; then the body is in equilibrium.

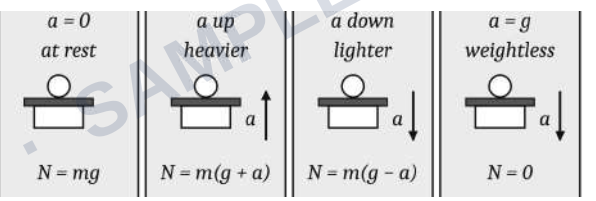

Fig. 4.8 Apparent weight in a lift

> **Illustration:** A 50 kg person ($g = 10$ m/s^2) stands on a scale in a lift accelerating at 2 m/s^2. Going up: $N = 50 \times 12 = 600$ N, scale shows 60 kg. Going down: $N = 50 \times 8 = 400$ N, scale shows 40 kg.

09) Circular Motion and Banking of Roads ★

Net inward force $F = \frac{mv^2}{r} = m\omega^2 r$ (supplied by friction, tension, gravity or N).

Case	*Result*
Banked road with friction, $\mu_s \tan\theta < 1$	$v_{\max} = \sqrt{rg\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}}$
Stone on a string, horizontal circle on a smooth table	$T = m\omega^2 r$

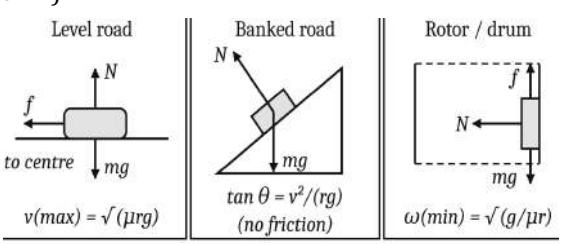

Fig. 4.9 Level road, banked road and rotor

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Rotor wall ($N = m\omega^2 r$, $\mu_s N \geq mg$)	$\omega_{\min} = \sqrt{g/(\mu_s r)}$
Ideal banking (no friction) or aircraft turn (tilted lift) $\tan\theta = \frac{v^2}{rg}$; *at* $v = \sqrt{rg}$, $\theta = 45°$	

Illustration: Level curve ($g = 10$ m/s^2), $r = 50$ m, $\mu = 0.5$: $v_{\max} = \sqrt{\mu r g} = \sqrt{250} \approx 15.8$ m/s (57 km/h). Same curve banked at 37° with no friction: $v = \sqrt{rg\tan\theta} = \sqrt{375} \approx 19.4$ m/s.

10) Collisions

NCERT treats collisions in Ch 5 (Work, Energy and Power); AAI asks them with this chapter.

Momentum is conserved in every collision of an isolated system;

KE only in an **elastic** one. Non Elastic Stick together: $v = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}$.

Coefficient of restitution: $e = \frac{v_2 - v_1}{u_1 - u_2}$.

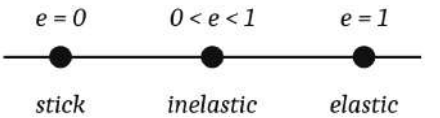


Fig. 4.10 Collision type by e

1-D elastic: $v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2}$, $v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2}$; e qual masses exchange velocities.

Units and values: g = 10 m/s^2 unless stated; 1 N = 1 kg m/s^2; 1 kgf = 9.8 N; 1 N s = 1 kg m/s; 1 rev = 2π rad; μ has no unit.

Key Formulas to Remember

- *Second law:* $F = \frac{dp}{dt} = ma$; $F_x = ma_x$, $F_y = ma_y$
- *Impulse:* $J = F\Delta t = \Delta p$ (area under F–t)
- *Recoil:* $V = -\frac{m}{M}v$ (gun M)
- *Friction:* $f_s \leq \mu_s N$, $f_k = \mu_k N$
- *Angle of repose:* $\tan\theta_r = \mu_s$
- *Lift reading:* $N = m(g \pm a)$ (+ for a up)
- *Level curve:* $v_{\max} = \sqrt{\mu_s r g}$

Exam Traps

▲ Block at rest under push: friction equals the applied force. Use $\mu_s N$ only at the verge of sliding, $\mu_k N$ once sliding. (PYQ 06, 20)

▲ Convert first: $\omega = 2\pi n/60$ (n in rpm); km/h to m/s: × 5/18. Check units before putting numbers in. (PYQ 24, 27)

▲ If $\mu_s = \tan\theta$ on an incline, the block is just in equilibrium: $a = 0$, not $g\sin\theta$. (PYQ 11)

▲ Scale reading in kg is N/g: 300 N on the scale means 30 kg, not 300 kg. (PYQ 07)

▲ N and mg on one block are not a third-law pair; a pair acts on two different bodies. (PYQ 12)

Shortcuts

➤ Braking on a rough level road: stopping distance $s = \frac{v^2}{2\mu g}$; the mass does not matter.

➤ Force F on m_1, with m_2 tied or touching behind it: the push or tension on m_2 is $F \times \frac{m_2}{m_1 + m_2}$. Check: 600 N on 10 kg, 20 kg behind: $600 \times \frac{20}{30} = 400$ N.

➤ Pull at θ above horizontal: $N = mg - F\sin\theta$ (less friction); push at θ below: $N = mg + F\sin\theta$.

➤ Climber accelerating up: $T = m(g + a)$; at constant speed $T = mg$. Check it against the rope's breaking tension.

Previous Year Questions

01) What will be the maximum speed with which a car can take a turn around a curve of 20 m radius on a level road if the coefficient of friction between the tyres and the road is 0.4? (Take g = 10 m/s^2)

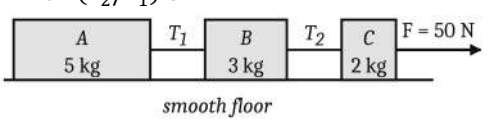
(A) $4\sqrt{5}$ m/s **(B)** $2\sqrt{5}$ m/s
(C) 80 m/s **(D)** 20 m/s
14 July 2025, Shift 2

02) The law of static friction can be written as: (where f_s is the static friction, μ_s is coefficient of static friction and N is normal reaction)

(A) $f_s < \mu_s N$ **(B)** $f_s \geq \mu_s N$
(C) $f_s > \mu_s N$ **(D)** $f_s \leq \mu_s N$
14 July 2025, Shift 2

03) Three blocks A (5.0 kg), B (3.0 kg) and C (2.0 kg) lie on a horizontal smooth surface. They are connected by light strings parallel to the surface. Block C is pulled horizontally with a force of 50 N. Let T_1 and T_2 be the tensions in string connecting A to B and B to C, respectively. Then $(T_2/T_1)$is:

(A) 5/8
(B) 4/3
(C) 8/5
(D) 3/4



27 December 2023, Shift 1

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19) Two bodies A and B of masses 2 kg and 6 kg in contact with each other rest on a table against a rigid wall. The coefficient of friction between the bodies and the table is 0.20. A force of 200 N is applied horizontally to A. Find the net force on the partition?

(A) 184 N
(B) 216 N
(C) 16 N
(D) 177.5 N



25 March 2021, Shift 2

20) Static friction is a self-adjusting force up to its limit _____. Do not put _____ without being sure that the maximum value of static friction is coming into play.

(A) $\mu_s N\ (f_s \geq \mu_s N), f_s < \mu_s N$
(B) $\mu_s N\ (f_s \geq \mu_s N), f_s = \mu_s N$
(C) $\mu_s N\ (f_s = \mu_s N), f_s = \mu_s N$
(D) $\mu_s N\ (f_s \leq \mu_s N), f_s = \mu_s N$

25 March 2021, Shift 2

21) Which of the following is the correct expression for maximum possible speed of a car on a banked road?

(A) $v_{max} = \sqrt{\mu_s Rg}$
(B) $v_{max} = \left(Rg\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}\right)$
(C) $v_{max} = \left(Rg\frac{\sqrt{\mu_s+\tan\theta}}{\sqrt{1-\mu_s\tan\theta}}\right)$
(D) $v_{max} = \left(Rg\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}\right)^{1/2}$

25 March 2021, Shift 2

22) A stream of water flowing horizontally with a speed of 20 m/s pushes out of a tube of cross-sectional area 10^{-1} m^2 and hits at a vertical wall nearby. Find the force exerted on the wall by the impact of water, assuming that it does not rebound?

(A) 40000 N **(B)** 400 N
(C) 2250 N **(D)** 4000 N

25 March 2021, Shift 3

23) Figure-out the case from the following in which the rope will break if an animal of mass 30 kg climbs on a rope, which can stand a maximum tension of 560 N. Assume g = 10 m/s^2

(A) 8 m/s^2 **(B)** 9 m/s^2
(C) 8.5 m/s^2 **(D)** 7 m/s^2

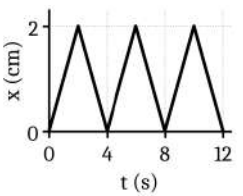
25 March 2021, Shift 3

24) A train runs along an unbanked circular track of radius of 10 m at speed of 36 km/h. The mass of the train is 10^6 kg. What is the angle of banking required to prevent wearing out of the rail? Assume g = 10 m/s^2

(A) 45° **(B)** 37° **(C)** 27° **(D)** 60°

25 March 2021, Shift 3

25) The below figure shows a ball of mass 0.6 kg rebounding between two walls separated by 2 cm. The ball rebounds between the walls every 2 seconds with a uniform velocity. Find the magnitude of each impulse?



(A) 1.2 × 10^{-2} kg m/s **(B)** 8 × 10^{-4} kg m/s
(C) 12 × 10^{-2} kg m/s **(D)** 8 × 10^{-2} kg m/s

25 March 2021, Shift 3

26) A 60 kg man stands in contact against the inner wall of a hollow cylindrical drum of radius 4 m rotating about its vertical axis with 180 rev./min. The coefficient of friction between the wall and his clothing is 0.20. Find the minimum rotational speed of the cylinder to enable the man to remain stuck to wall (without falling) when the floor is suddenly removed? Assume g = 10 m/s^2.

(A) √22.2 rad/s **(B)** √12.5 rad/s
(C) √18.2 rad/s **(D)** √23.5 rad/s

25 March 2021, Shift 2

27) A stone of mass 0.3 kg tied to the end of a string is whirled round in a circle of radius 1.2 m with a speed of 20 rev./min in a horizontal plane. What is the tension in the string? What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 100 N?

(A) 0.75 N, 20 m/s **(B)** 6.57 N, 34.6 m/s
(C) 6.57 N, 39.6 m/s **(D)** 1.57 N, 20 m/s

25 March 2021, Shift 3

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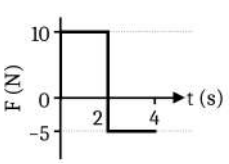
Practice Questions

Level: ● Easy ●● Moderate ●●● Tough

01) A three-wheeler of total mass 465 kg moving at 36 km/h is brought to rest in 4.0 s. The average retarding force on it is ●●

(A) 4650 N **(B)** 1162.5 N
(C) 2325 N **(D)** 581 N

02) A 2 kg body at rest is acted on by the force shown in the F–t graph. Its speed at t = 4 s is ●●



(A) 10 m/s **(B)** 5 m/s
(C) 15 m/s **(D)** 2.5 m/s

03) A gun of mass 200 kg fires a 0.05 kg shell with a muzzle speed of 400 m/s. A constant resisting force brings the recoiling gun to rest in 0.5 s. The magnitude of this force is ●●

(A) 0.2 N **(B)** 20 N **(C)** 40 N **(D)** 4 N

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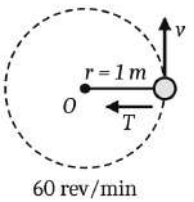
20) A 0.5 kg stone tied to a string is whirled in a horizontal circle of radius 1 m at 60 rev/min (top view). The tension in the string is about



(A) 9.9 N **(B)** 4.9 N **(C)** 39.5 N **(D)** 19.7 N

Previous Year Questions – Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
01	A	02	D	03	C	04	C	05	D	06	C	07	D	08	A	09	D	10	C
11	D	12	D	13	D	14	C	15	C	16	C	17	B	18	A	19	A	20	D
21	D	22	A	23	B	24	A	25	A	26	B	27	D						

Practice Questions – Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
01	B	02	B	03	C	04	C	05	A	06	D	07	B	08	C	09	B	10	A
11	D	12	A	13	D	14	A	15	C	16	B	17	D	18	A	19	C	20	D

Previous Year Questions – Hints and Solutions

01) (A) Level road: friction gives the centripetal force, $\mu mg = \frac{mv^2}{r}$ So; $v_{\max} = \sqrt{\mu rg} = \sqrt{0.4 \times 20 \times 10} = \sqrt{80} = 4\sqrt{5}$ m/s; **Trap:** 80 m/s forgets the square root

02) (D) Static friction adjusts itself up to its limit: $f_s \leq \mu_s N$
Equality holds only when sliding is just about to start

03) (C) Smooth floor: $a = \frac{F}{\sum m} = \frac{50}{10} = 5$ m/s²
T_1 pulls only A: $T_1 = 5 \times 5 = 25$ N; T_2 pulls A + B: $T_2 = 8 \times 5 = 40$ N; $\frac{T_2}{T_1} = \frac{40}{25} = \frac{8}{5}$
T_2 pulls A and B (8 kg), not only B; swapping gives 5/8

04) (C) No external horizontal force: total momentum stays zero
$60v + 2 \times 3 = 0 \Rightarrow v = -0.1$ m/s, i.e. −(0.1 m/s) î (Rahul recoils)
Trap: the minus sign matters; (D) has the right size but the wrong direction

05) (D) Friction is the centripetal force: $\mu mg = \frac{mv^2}{R}$
$v_{\max} = \sqrt{\mu Rg}$ (independent of mass)
Trap: μ multiplies Rg inside the square root, not outside it

06) (C) Block does not move, so static friction balances the push $f = F = 50$ N (not μmg)
Trap: 200 N is the weight mg, not the friction

07) (D) Going down with a: $R = m(g - a) = 60(10 - 5) = 300$ N; Scale reading: $\frac{R}{g} = \frac{300}{10} = 30$ kg
Trap: 300 is in newtons, not kg

08) (A) Block just starts sliding at 30°, so 30° is the angle of repose $\mu_s = \tan 30° = \frac{1}{\sqrt{3}}$
Trap: use tan, not sin (1/2) or cos

09) (D) $a = \frac{F}{m} = \frac{10}{2} = 5$ m/s²
Acceleration is along the force, i.e. east

10) (C) Once outside, no force acts on the astronaut (no gravity, no contact)
By the first law, $a = 0$; the ship's 60 m/s² is irrelevant

11) (D) Needed friction $mg\sin 30°$; maximum available $\mu_s mg\cos 30° = \frac{1}{\sqrt{3}} \cdot mg\frac{\sqrt{3}}{2} = mg\sin 30°$
Friction can just hold the block, so $a = 0$

12) (D) Action and reaction act simultaneously, on different bodies

13) (D) Momentum conserved: $600V = 5 \times 40$
$V = \frac{200}{600} = \frac{1}{3}$ m/s (opposite to the ball)
Trap: the recoil speed is 1/3 m/s, directed opposite to the ball

14) (C) Perfectly inelastic: $m_1u_1 = (m_1 + m_2)v$
$v = \frac{0.4 \times 6}{1.2} = 2$ m/s
Trap: divide by the total mass 1.2 kg, not 0.8 kg

15) (C) Slope of the v–t graph: $a = \frac{0-80}{8-0} = -10$ m/s²
Friction $F = ma = 0.25 \times (-10) = -2.5$ N (opposes motion)
Trap: convert 250 g to 0.25 kg; keep the minus sign of a
Note: AAI's printed key differs; the correct value is −2.5 N, option (C).

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Chapter 1

Sets

1. **Sets:** A set is defined as a well-defined collection of *objects*.
   Notation: Sets are typically denoted by uppercase letters such as A, B, C, etc.
   Special Sets: These are common sets that include elements like Natural Numbers, Integers, Rational Numbers, etc.
   Notation: Examples of these sets are represented by symbols like N (Natural Numbers), Z (Integers), Q (Rational Numbers), R (Real Numbers), and ϕ (Empty Set).

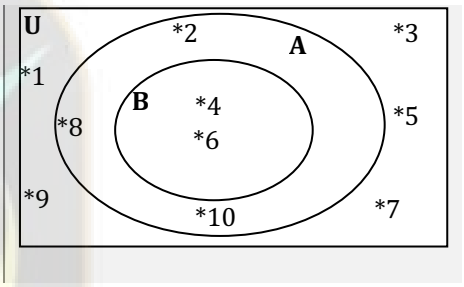
2. **Types of Sets**

Empty set	A set with no elements	$\Phi = \{\}$
Finite set	Contains a specific number of elements	$A = \{1, 2, 3\}$
Infinite set	Contains an unending number of elements	$N = \{1, 2, 3, \dots\}$
Equal sets	Sets with the same elements	$A = \{1, 2\}, B = \{2, 1\} \Rightarrow A = B$

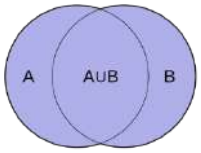
2. Representation of Sets

Roster form	Lists elements explicitly	$\boldsymbol{A = \{1, 2, 3\}}$
Set-builder form	describes elements by property	$A = \{x \mid x \text{"{ is a prime}}\}$

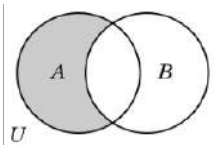
3. **Subsets and Universal Set**
   - $A \subset B$: *Every element of set A is also an element of set B. Example:* $A = \{1, 2\}, B = \{1, 2, 3\}$
   - $A \subsetneq B$: *Set A is a subset of B, but A is not equal to B. Example:* $A = \{1\}, B = \{1, 2\}$
   - U: *The universal set, containing all elements under consideration for a particular discussion or problem. Example:* $U = \{1, 2, 3, 4, 5\}$
   - *In the given fig. U = {1,2,3, ..., 10} is the universal set of which A = {2,4,6,8,10} and B = {4, 6} are subsets, and B⊆A.*



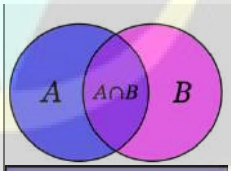
4. **Operations on Sets**



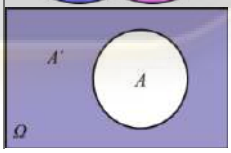
Union $A \cup B$
Set of elements in A or B (or both)
$A \cup B = \{x: x \in A \text{ or } x \in B\}$



Difference $A - B$
Elements in A but not in B
$A - B = \{x : x \in A \text{ and } x \notin B\}$



Intersection $\boldsymbol{A \cap B}$
Set of elements common to both A and B
$A \cap B = \{x: x \in A \text{ and } x \in B$



Complement A' Elements in U that are not in A
$A' = \{x: x \in U \text{ and } x \notin A\}$

5. **Power Set** A power set is the set of all subsets of a given set. If a set has n elements, its power set has 2^n elements. $\mathbf{n(P(A)) = 2^n}$

Set A	*Power Set P(A)*	*n(P(A))*
{1,2}	{∅,{1},{2},{1,2}}	4

6. **Number of Subsets and Proper Subsets** For a set having n elements:

Type	*Formula*
Total subsets	2^n
Proper subsets	$2^n - 1$
Non-empty subsets	$2^n - 1$
Non-empty proper subsets	$2^n - 2$

7. **Cardinality of Two Sets** Used directly in Venn diagram questions.
   Formula: n(A ∪ B) = n(A) + n(B) − n(A ∩ B)
   Neither formula: Neither = n(U) − n(A ∪ B)

8. **Cardinality of Three Sets** Important for higher-level Venn diagram questions.
   Formula: n(A ∪ B ∪ C) = n(A)+n(B)+n(C)−n(A∩B)−n(B∩C)−n(C∩A)+n(A∩B∩C)

9. **Disjoint Sets** Two sets are disjoint if they have no common element. **Formula:** A ∩ B = ∅
   For disjoint sets: n(A ∪ B) = n(A) + n(B)

10. **Symmetric Difference** Symmetric difference contains elements present in A or B but not in both.
    Formula: A △ B = (A − B) ∪ (B − A)
    Useful identity: A △ B = (A ∪ B) − (A ∩ B)

11. **Important Set Identities**

Law	*Formula*
Idempotent Law	A ∪ A = A, A ∩ A = A
Absorption Law	A ∪ (A ∩ B) = A
Absorption Law	A ∩ (A ∪ B) = A

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Double Complement	$(A')' = A$
Complement of U	$U' = \emptyset$
Complement of ∅	$\emptyset' = U$

12. Interval Representation

Type	*Notation*	*Meaning*
Open interval	(a,b)	$a < x < b$
Closed interval	[a,b]	$a \le x \le b$
Left-closed	[a,b)	$a \le x < b$
Right-closed	(a,b]	$a < x \le b$
Real line except a	R – {a}	$(-\infty,a) \cup (a,\infty)$

13.Key Properties of Sets

Property Type	*Property*	*Formula*
Commutative Laws	Union and Intersection	$A \cup B = B \cup A, A \cap B = B \cap A$
Associative Laws	Union and Intersection	$(A \cup B) \cup C = A \cup (B \cup C)$
Distributive Laws	Union over Intersection	$A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
Identity Laws	Union with Empty Set, Intersection with U	$A \cup \phi = A, A \cap U = A$; $A \cup \emptyset = A, A \cap U = A, A \cap \emptyset = \emptyset, A \cup U = U$
Complement Laws	Union and Intersection with Complements	$A \cup A' = U, A \cap A' = \emptyset$
De Morgan's Laws	Complement of Union and Intersection	$(A \cup B)' = A' \cap B', (A \cap B)' = A' \cup B'$

14.Intervals as Subsets of *R*

- **Open Interval:** Notation (a, b) Represents points x where $a < x < b$. Example: $(1,3) = \{1 < x < 3\}$
- **Closed Interval:** Notation $[a, b]$ Represents points x where $a \le x \le b$. Example: $[1,3] = \{1 \le x \le 3\}$
- **Half-Open Intervals:** Notation $[a, b)$ Or $(a, b]$ Represents points x including one endpoint but not the other. Example: $[1,3) = \{1 \le x < 3\}$

15.Summary of Important Formulas

Union	$A \cup B = \{x: x \in A \text{ or } x \in B\}$
Intersection	$A \cap B = \{x: x \in A \text{ and } x \in B\}$
Difference	$A - B = \{x: x \in A \text{ and } x \notin B\}$
Complement	$A' = \{x: x \in U \text{ and } x \notin A\}$
De-Morgan's Laws	$(A \cup B)' = A' \cap B', (A \cap B)' = A' \cup B'$

Key Formulas to Remember

- *Associative (intersection):* $(A \cap B) \cap C = A \cap (B \cap C)$
- *Distributive (intersection over union):* $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$
- *Cartesian product:* $A \times B = \{(a, b): a \in A, b \in B\}$ *and* $n(A \times B) = n(A) \cdot n(B)$
- *Difference:* $A - B = A \cap B'$ *and* $n(A - B) = n(A) - n(A \cap B)$
- *Symmetric difference:* $n(A \triangle B) = n(A) + n(B) - 2n(A \cap B)$
- *Exactly two of three sets:* $\sum n(A \cap B) - 3n(A \cap B \cap C)$
- *Exactly one of three sets:* $\sum n(A) - 2\sum n(A \cap B) + 3n(A \cap B \cap C)$
- *Number sets:* $\mathbb{N} = \{1,2,3, \ldots\}, \mathbb{W} = \{0,1,2, \ldots\}, \mathbb{Q}^c$ = *irrationals*

Previous Year Questions

01) Which of the following is a subset of the set of isosceles triangles?

(A) Set of all right-angled triangles
(B) Set of all scalene triangles
(C) Set of all equilateral triangles
(D) Set of all triangles
14 July 2025, Shift 1

02) If A is the set of positive rational numbers and B is the set of natural numbers, then which of the following is not a universal set for A and B?

(A) $\mathbb{Q} \cup \mathbb{N}$
(B) $\mathbb{R} \backslash \mathbb{N}$
(C) $\mathbb{Q}^+$
(D) $\mathbb{R}$
14 July 2025, Shift 1

03) Which of the following is a set?

(A) A team of eleven best-cricket batsmen of the world
(B) The set of letters in the English Alphabet
(C) A collection of most dangerous animals of the world
(D) The collection of ten most talented writers of India
14 July 2025, Shift 1

04) Which of the following is a universal set of $\mathbb{Q}$ x $\mathbb{N}$ and $\mathbb{N}$ x $\mathbb{Q}^c$?

(A) $\mathbb{R} \times \mathbb{Q}^c$
(B) $\mathbb{Q}$ x $\mathbb{R}$
(C) $\mathbb{R} \times \mathbb{N}$
(D) $\mathbb{Q}$ x $\mathbb{Q}^c$
14 July 2025, Shift 1

05) Which of the following is a non-empty finite set?

(A) $D = x: x^2 - 2 = 0$ and x is a rational number
(B) $A = x \in \mathbb{N}$ and $2x - 1 = 0$
(C) $C = x: x \in \mathbb{N}$ and $x^2 = 4$
(D) $B = x: x$ is an even prime number greater than 2

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14 July 2025, Shift 2

06) Which of the following is an infinite set?
(A) The set of all rational numbers between 0 and 1
(B) The set of prime numbers less than 99
(C) The set of all leaves on all the trees on earth
(D) The set of all insects on earth
14 July 2025, Shift 2

07) The set $\{x \in \mathbb{R}: x \neq 1\}$ is a/ an _____.
(A) interval
(B) union of four disjoint open intervals
(C) union of three disjoint open intervals
(D) union of two disjoint open intervals
14 July 2025, Shift 2

Exam note: AAI's answer key is doubtful – correct answer: union of two disjoint open intervals.

08) Which of the following represents an empty set?
(A) Set of Vowels in the word SYNCH
(B) Set of Prime numbers lesser than 10
(C) Set of Consonants in the word GIRLS
(D) Set of Months of a year starting with the letter A
27 December 2023, Shift 1

09) If $A = (45, 54, 63, 72\}, B = \{54, 81, 90\}$ *and* $C = \{45, 54, 60\}$, what is $(A \cup B) \cap C$?
(A) {45, 54, 60, 63, 72}
(B) {54}
(C) {45, 54, 60, 63, 72, 81, 90}
(D) {45, 54,}
27 December 2023, Shift 2

10) *If* $P = \{x : x = 6n, where\ n \in N, n \leq 8\}$ *and* $Q = \{x : x = 8n, where\ n \in N, n \leq 10\}$. *What is* $P - Q$?
(A) {6, 8, 12, 18, 24, 30, 36, 40}
(B) {24, 48}
(C) {6, 8, 12, 16, 18, 24, 30, 32, 36, 40, 42, 48, 56, 64, 72, 80}
(D) {6, 12, 18, 30, 36, 42}
27 December 2023, Shift 2

11) In a group of 95 people, 59 like tea, 33 like coffee and 17 people likes both tea and coffee. How many people like neither tea nor coffee?
(A) 59
(B) 20
(C) 33
(D) 95
27 December 2023, Shift 3

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Answer Key

Q.No.	Answer	Q.No.	Answer	Q.No.	Answer	Q.No.	Answer	Q.No.	Answer	Q.No.	Answer
01	C	02	B	03	B	04	B	05	C	06	A
07	D	08	A	09	D	10	D	11	B		

Hints and Solutions

01) Isosceles triangle → at least two equal sides
Equilateral triangle → all three sides equal ⇒ also has at least two equal sides. So, every equilateral triangle is an isosceles triangle. Other options do not always satisfy this. **Ans (C)**

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